spension, and they inclosed the whole apparatus in a shed, so that it might be kept permanently inflated and await calm days for experiment. This air-ship, which was named La France, held 65,836 cub. ft. of hydrogen, and its lifting power was 4,402 lbs. The car was very long (105 ft.), in order to equalize the weight over the balloon and yet admit of both being placed close together, in order to bring the propelling arrangements as near the center of gravity as possible. The screw was placed on the car: it had two arms, and was 23 ft. in diameter. The power of the motor was ascertained by experiment in the shop to amount to 9 horse-power, and speeds of 17 to 20 miles per hour were expected with 46 revolutions of the screw. Fig. 2 represents this air-ship. Experiments made with La France gave a speed of 14 miles per hour with an electric motor of 9 horse-power, weighing, with its primary battery, 1,174 lbs., this being the utmost that the air-ship could lift, in addition to its own weight and that of the aëronauts and their supplies. Further calculations show that by simply doubling the dimensions of the balloon its lifting power will be so much increased that a motor weighing at the same rate—130 lbs. per horse-power—will produce a speed of 25 miles per hour. This, however, depends upon the practicability of a balloon 330 ft. long—which remains to be proved. Commandant Renard, after stating that "the conquest of the air will be practically accomplished when a speed of 28 miles per hour is obtained," expresses the opinion that we are on the eve of freely navigating the air, and that probably France will possess the first aërial fleet. It is stated that the German, Russian, and Portuguese Governments have recently organized aëronautical establishments, and are experimenting in secret. Should some notable success follow, it will not be the first time that a great invention has been advanced by the necessities of war. Leaving speculation, however, the accompanying table gives the principal data as to the four air-ships which have been described, and the horse-power necessary to drive them at 25 miles per hour. The last line shows how light a motor must be to produce 25 miles per hour without increasing the weight.

Schedule of Navigable Balloons.

DATA.		Giffard, 1852.	Dupuy de Lôme, 1872.	Tissandier, 1883.	Renard and Krebs, 1884–'85.
Length, out to out	ft.	144·3	118·47	91·84	165·21
Diameter, largest section	"	39·3	48·67	30·17	27·55
Length to diameter	proportion	3·67 to 1	2·43	3·04	6
Cubic contents	ft.	88,300	120,088	37,439	65,836
Ascending power	lbs.	3,978	8,358	2,728	4,402
Weight—Balloon and valves	lbs.	704	1,255·5	374	812
" Netting and bands	"	330	396	154	270
" Spars and adjuncts	"	660	1,316·5	75	170
" Rudder and screw	"	....	165	...	193
" Anchor and guide-rope	"	176	308	110	....
" Car complete	"	924	1,287	220	995
" Motor in working order	"	462	2,000	616	1,174
" Aëronauts	"	154	310	330	308
" Ballast and supplies	"	567·6	1,320	849	471
" Total apparatus	lbs.	3,977·6	8,358	2,728	4,402
Horse-power of motor		3	0·8	1·5	9
Weight of motor per horse-power	lbs.	154	2,500	410	120
Speed obtained	miles per hour	6·71	6·26	6·71	14
Horse-power required 25 miles per hour		155	52 (?)	77	51
Motor lbs. per horse-power		3	38 (?)	8	23

Possible Improvements in Balloons.—The greatest speed thus far attained has been 14 miles per hour, which is insufficient to cope with most of prevailing winds, particularly at sailing heights above the ground, and the following difficulties have been encountered and to a certain extent overcome:

1. Excessive loss of gas in early experiments. This has been remedied by closer tissue of envelope and better varnishes, as well as by regulating valves, so that the loss of gas has been reduced so as to average less than 2 per cent per day.

2. Resistance of air to forward motion. This has been largely diminished by pointed ends, but much remains to be done in ascertaining the best proportions.

3. Need of a propeller to act on the air. This has been measurably solved by the aërial screw, which is said to exert from 50 to 70 per cent. of the power applied, but is yet less efficient than the marine screw, which works up to 84 per cent.

4. Need of steering gear. This has been fairly worked out by various arrangements of rudders and keel cloths, which have given command of the apparatus when in motion.

5. Need of a light motor. This is the great difficulty. Steam has been tried with a weight of 154 lbs. per horse-power, including fuel and water, and electric engines with a weight of 130 lbs. per horse-power. Neither are sufficiently light to give the necessary speed, except for very large apparatus.

6. Need of endwise stiffness. This has been remedied by compressing the gas inside the balloon, either through the use of a loaded safety-valve or through the use of an internal air-bag. As speed increases more will needs be done in this direction, and this will require stronger and heavier envelopes for the gas-bag.

rmy days; but the cargoes carried in proportion to the size will be small, and to obtain eeds similar to those of express trains some other form of apparatus will have to be sought r.

War Balloons in the Field.—The ingenious appliances which were used by Italy during e recent Abyssinian War are illustrated in Figs. 3, 4, and 5. Abyssinia is not a country in which the gas necessary for the inflation of balloons can be easily procured. It was necessary to provide an apparatus for the production of the gas, and to find a fit means of transporting it across the desert. Fig. 3 represents a balloon ascent in the field. The inflation has just been effected, and the balloon, held by a rope attached to a windlass, is swaying in the air. In countries provided with gas-works, the inflating is usually effected by means of illuminating gas, and it is only necessary to connect the balloon with one of the city mains. In the case under consideration, the gas, produced by a process hereafter explained, was contained in forty tubes, united in two groups of twenty, with a barrel that supplied the conduit, which ends at the place where the balloon is located in the center of a circle of ballast-bags. Around the drum of the windlass winds the cable, the extremity of which is affixed to a trapeze that surrounds the car. Within the cable, which is of several strands, there are two telephone wires, which are not exactly in the center, but a little to one side, in order that, in case of a breakage, the point where the accident occurred may be known at once. By this means the balloon is constantly in communication with those who remain below, who can instantaneously pay out or draw in the cable at will. It takes ten men to do the manœuvring, the traction to be exerted not exceeding 650 lbs. in a pretty swift wind, and but 325 lbs. in a dead calm. These balloons are wholly of silk, and are so pliable that each fits into its car, which has a capacity of but 35 cub. ft. The whole is contained in a compartment in the hind carriage of the vehicle (Fig. 4), the front part of which is occupied by the windlass. The carriage is very low, and is built to withstand hocks and jolting. It requires but two horses to draw it, since the whole weighs but about 425 lbs. The hydrogen is prepared in a special apparatus, represented in Fig. 5. This apparatus, which is quite cumbersome, can not be carried everywhere, and so, in certain cases, e gas must be carried all prepared. In order to reduce its volume, the idea has occurred to npress it under very great pressure into very strong steel cylinders. Each of these latter ghs 65 lbs., and is 8 ft. in length, 5 in. in diameter, and ¼ in. in thickness. The gas is erved therein, without any loss, at a pressure of 135 atmospheres. It takes from 70 to 75 hese cylinders to inflate a balloon of 10,500 cub. ft. They are borne upon another car- e, and, as their total weight is between 4,400 and 5,000 lbs., they can be easily hauled by horses. In Abyssinia, when the land did not allow of the passage of a vehicle, these ders were carried upon the backs of camels. In the operation of inflating, but one cyl-

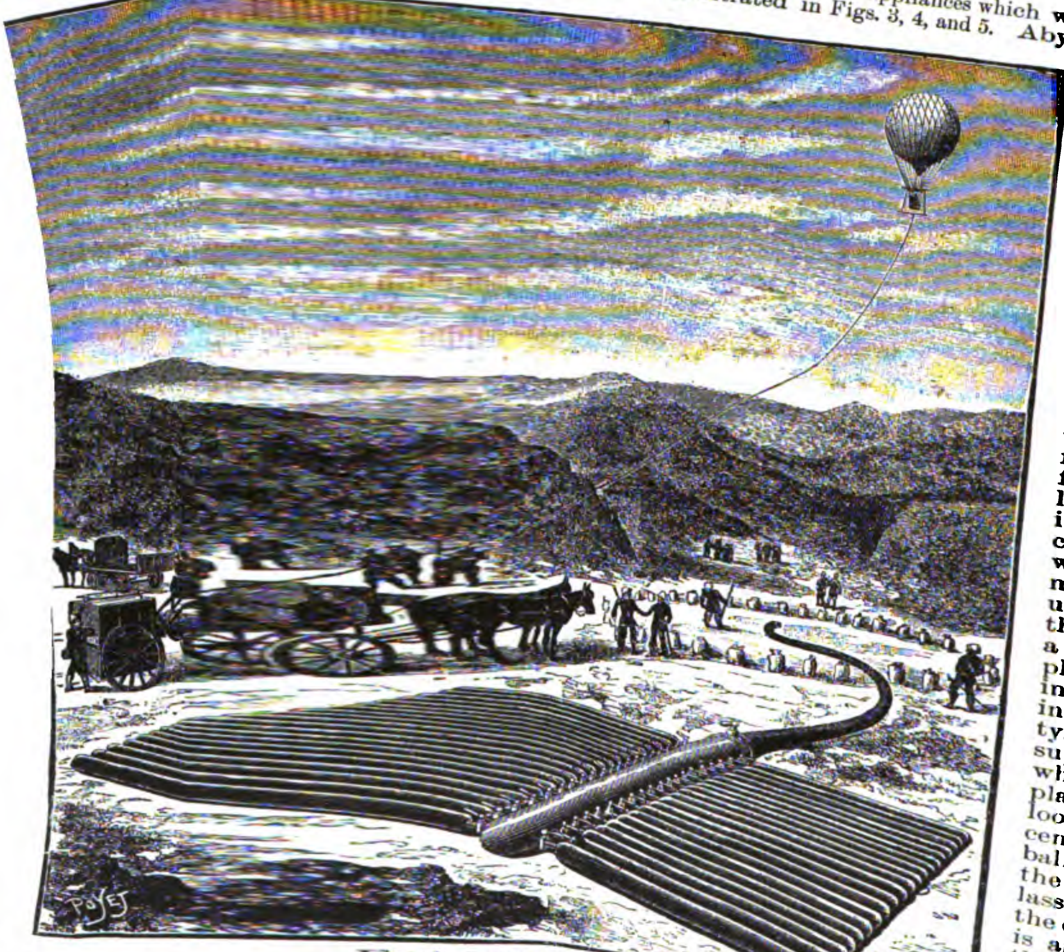


FIG. 3.—Balloon operations in Abyssinia.

e same make, are said to have flown up to a height of 25 ft. and a dis-
ι slightly adverse wind. The relative power absorbed, however, is quite
any known prime motor.
ial Butterfly (Fig. 7) is an example of an aërial screw used to sustain
ously by its horizontal revolutions. It has been proved, however, that about 1 horse-power of energy is required to sustain 33 lbs. in the air. Fig. 8 represents a similar contrivance propelled by two screws. The motive power in both devices is furnished by a twisted rubber cord.

Hargrave's Flying-Machines.—Mr. Laurence Hargrave, of Sydney, New South Wales, has been experimenting for many years with models of flying-machines, and has succeeded in getting longer flights than any hitherto obtained. Up to December 3, 1890, he had constructed nine aëroplanes, operated by bands of India-rubber and propelled by wings; one operated by rubber bands and a screw; two operated by compressed air, with wings; and two operated by means of a cross-bow, with wings. From Mr. Hargrave's experiments he concludes that the wing and the screw are about equally efficient in

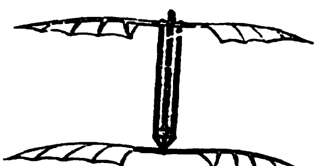


FIG. 8.—Mechanical bird.

fly.

-propelled aëroplane weighed 2 lbs. and was driven by the contractile
nds, geared in tension, a horizontal distance of 120 ft., by the expendi-
ls. Another machine in which flapping wings were similarly driven,
w a distance of 270 ft. with 470 foot-pounds of energy. In 1890 he
essed-air flying-machine, shown in Fig. 9. The body of the machine
in diameter and 48½ in. long, weighing 19¼ oz., and with a capacity of
ls the compressed air at a working pressure of 230 lbs. to the sq. in.

9.—Hargrave's flying-machine.

The engine cylinder is 1¼ in. diameter and 1½ in. stroke, the total weight of the compressed-air engine being 6½ oz. The area of the aëroplane measures 2,128 sq. in., and that of the wings is 216 sq. in., thus giving a total area of 2,344 sq. in. for a total weight of 2·53 lbs. The wings are made of paper, and have no feathering motion, save that due to the elasticity of the material of which they are composed. In a dead calm the machine flew 368 ft. horizontally, with an expenditure of 870 foot-pounds of energy. The engraving shows also two
pumps. (See *Engineering*, December 26, 1890; also *Journal of the*
outh Wales, vol. xxiv.)

Bird, devised by M. Gustave Trouvé, Fig. 10, is claimed by its
machine which has risen into the air by its own unaided force.
o wings, *A* and *B*, connected by a "Bourdon" bent tube, such
ges, the peculiarity of which is that when pressure increases within
move apart, and return toward each other upon diminished press-
ses the efficiency of this action by putting a second tube within
s therein a series of alternate compressions and expansions, by ex-
s contained in the revolver-barrel, *D*, which communicates with the
explosions produce a series of strokes of the wings, which, with the
g-plane, indicated at *C*, both support and propel the bird in the air.
it is represented in Fig. 11. The bird is suspended from a frame by
hammer of the revolver, thus keeping it up from the cap. Another
ar the upright post, while a common candle, *A*, and a blow-pipe
reparations. Upon the thread being burned at *A*, the bird swings
to position *2*, when, the other thread being burned by the flame, the

ıemoir to the French Academy of Sciences, July 13, 1891:
made during the last four years have been executed with an
ıs about 20 metres in diameter, put in movement by a 10
y are chiefly as follows: 1. To compare the movements of
weights, surface, form, and variable arrangements, the whole
ition, but disposed in such a manner that it could fall freely.
sary to move such planes or systems of planes, when they are
fficient for them to be sustained by the reaction of the air in
tal flight. 3. To examine the motions of aërostats provided
ous other analogous questions that I shall not mention here.
category of experiments which have been carried out, let us
by its own weight) with 464 grammes, having a length 0·914
ickness 2 mm., and a density about 1,900 times greater than
ed on in the direction of its length by a horizontal force, but
ıe below gives the horizontal velocities in metres per second;
ody took to fall in air from a constant height of 1·22 metres,
ıg 0·50 second:

....	0 m.,	5 m.,	10 m.,	15 m.,	20 m.
a constant height	0·53 s.,	0·61 s.,	0·75 s.,	1·05 s.,	2·00 s.

de under the best conditions, it is striking, because, the plane
no vertical component of apparent pressure to prolong the
the specific gravity is in this more than 1,900 times that of
is quite free to fall, it descends very slowly, as if its weight
r of times. What is more, the increase in the time of fall is
ı of the lateral movement. The same plane, under the same
oved in the direction of its length, gave analogous but much
observations of the same kind have been made in numerous
nd under more varied conditions. From that which pre-
y be deduced that the time of fall of a given body in air,
be indefinitely prolonged by lateral motion, and this result
o be taken of the inertia of air in aërial locomotion, a prop-
ıeglected in this case, has certainly not received up to the
to it. By this (and also in consequence of that which fol-
ssity of examining more attentively the practical possibility
ry—that of causing heavy and conveniently disposed bodies
el in air. In order to indicate by another specific example
in the second category of my experiments, I will cite the
ıe, but carrying a weight of 500 grammes—that is 5,880
ed at different angles, and moving in the direction of its
under the pressure of the air, as in the first example it was
its support, the velocity is regulated in such a manner that
izontal motion.

ving table gives the angle (a) with the horizon; the second
lanement—that is, the velocity which is exactly sufficient
movement, when the reaction of the air causes it to rise
ı indicates in grammes the resistances to the movement
forward for the corresponding velocities—a resistance that is shown by a dynamometer. These three columns only contain the data of the same experiment. The fourth column shows the product of the values indicated in the second and third—that is to say, the work T, in kilogram-metres per second, which has overcome the resistance. Final-
ıe weight in kilogrammes of a system of such planes that
ıse to advance horizontally with the velocity V, and at

$=\frac{VR}{1000}$	$P=\frac{500 \times 4554}{T \times 60 \times 1000}$
5·6	6·8
2·9	13·0
1·4	26·5
1·1	34·8
0·7	55·5
0·4	95·0

last column, it is necessary to add that my experiments
e may suppose such planes to have very small interstices,
wer of support of any of them. It is also necessary to
given here to the planes have only the object of facilitat-
I have found that surfaces approximately plane, and
ntly strong to be employed in flight, such as has been
ease more than 85 kilogrammes are disposable for motors
of fact, complete motors weighing less than five kilo-
ntly been constructed. Although I have made use of
nts, I do not regard this form of surface as that which
fore, that the weights I have given in the last column

stat: see Aërial Navigation.
RICULTURAL MACHINERY. Machinery for agricultural purposes consists in:
ements for clearing land and for ditching. 2. Implements for preparing land for the
on of seed. 3. Implements for planting the seed. 4. Implements for the cultivation
growing plants. 5. Implements for harvesting crops. 6. Implements for preparing
ops for use. 7. Implements for miscellaneous agricultural purposes.
his classification conforms to the course of the farm history of the crop.
or information relating to farm appliances associated directly with tillage and crops see
TIVATORS; COTTON-GIN; CARRIAGES AND WAGONS; CREAMERS; DITCHING MACHINES;
VATORS; ENSILAGE MACHINES; HAY CARRIER; HAY LOADER; HAY-RAKE: HORSE-POWER;
RVESTING MACHINERY; GRAIN HARVESTER; COTTON LOGGER; STEAM MILLING-MACHINES;
AIN-MOWERS; PLOWS; POTATO-DIGGER; PRESSES, HAY AND COTTON; PULVERIZERS AND
RROWS; REAPERS; SEEDERS AND DRILLS; SHEEP-SHEARING MACHINE; STALK CUTTERS;
UMP PULLERS; THRESHING MACHINE; WATER WHEELS.

In general, late tendencies are toward the substitution of metals for wood, and of rolled
d malleable irons and rolled steel in place of cast-iron parts in agricultural-machine struct-
e—a growing change especially noticeable in plows, harrows, seeders, harvest-machines, and
pparatus for handling the hay crop. This movement directs the effort of iron and steel
orkers to supplying the machine factories with the special forms possessing the qualities
ecifically required. It arises partly from a sensible natural limit to available supplies of
uitable hard woods in necessary lengths, and partly from a preference among farmers for
etallic machines, especially in those types which are subject to locomotion while working,
s the joints can be made permanently firmer under the racking strains of movement over
ough farm-land. It has stimulated the introduction of new processes in the great iron and
steel works for cold-rolling special forms, and for producing cast steel in forms convenient to
ut up into the shapes for making the tools and dies used in the agricultural-machine fac-
tories. Piping is also largely supplied for the framework of some of the harvest-machines.
Brass, aluminum-bronze, babbitt, and other composite-metal low-friction bearings are supplied
for the better grades of machines. Steel plates are rolled into rims for the light strong sup-
port-wheels, with any requisite ribs, nuptions, or other deviations rolled in to save factory
work. The steel spokes of machine wheels are rolled, tapering, with elliptic section, in pairs
butt to butt, and then sawed in two, for single spokes. Steel plates, formerly hand-ham-
mered, are rolled to ultimate shape for use. Steel plowshares are cast in a "chill"—that is,
a piece of cold metal of proper form is so introduced in the sand mold for the casting that
the part or parts of the casting which are to be hardened come in contact with it when
poured and instantly set, forming a hard skin of about $\frac{1}{16}$ in. in thickness on the softer and
tough interior of the casting. Tempered wire required for the machines is, by a recent in-
vention, automatically tempered to a reliable uniformity during the process of drawing.
Wheel rims and tires are welded instantaneously by the heat of an electric current. Cut
nails are superseded largely in machines by the new wire nails, round and of even diameter
throughout the shank, cheaper in production, tougher in fiber, more tenacious in the wood,
and of lighter weight than cut nails of like length. By what is known as "the Fitchburg
process" of rolling metals, extraordinary shapes are rolled out in one operation, very cheaply
where considerable quantities of a given shape are needed. Spiral springs in great variety
and cold-pressed nuts with the hole in are cheaply produced in high perfection. Reaper cut-
ter-bars, harvester frame-pieces, and plow-beams, formerly forged out by hand, are rolled
from the steel, trimmed with heavy boiler-iron shears, and when straightened in the hydraulic
press are ready for use. The work formerly done expensively and slowly upon them by the
milling-machine is now rapidly and cheaply accomplished by the means mentioned and with
satisfaction in results obtained. Largely owing to these improvements, introduced during
the last decade (1881–1890), the farmer buys machines affected by them for from 25 to 50 per
ent lower price than ten years ago. Another noticeable tendency is also seen toward complete
utomatic operation, with consequent economy of expenditure of skill, time, and money. The
armers of English-speaking countries, where this class of invention is rife, are adapting them-
lves with facility to the new methods of farming by machinery. Improved appliances in
e hands of a large portion of the farming community force others to employ like facilities
competition. Their use is steadily tending to become compulsory, not only in enterpris-
but in all other industrial regions of the world, under penalty of famine and kindred
mity—for the important and essential effect is not really so much "labor-saving" as
l-saving.

ir Blast: see Furnaces, Blast. Air, Compressed, Air Drill: see Coal-mining Ma-
s. Air Engine: see Engines, Air. Air Gun: see Gun, Pneumatic. Air Hammer:
ammers. Power. Air Ship: see Aërial Navigation. Air Torpedo: see Torpedo.

R, COMPRESSED, UTILIZATION OF. *Air-compressed Power Supply.*—The dis-
ion of power by means of compressed air carried in pipes from a central station to
distant points of application has been chiefly adopted in mining and tunneling, for
purposes it has manifest advantages over all other systems of transmission. It has
en introduced to some extent as a means of supplying power to small consumers in
s in Birmingham, England, and in Paris. The largest installation of the kind, the
Paris, is described in the *Proceedings of the Institute of Mechanical Engineers*, July,
om which we extract the following: "The works of the Compagnie Parisienne de
mprimé, started in 1881 by M. Victor Popp, and situated in Rue St. Fargeau, Paris,
te through some 40 miles of mains compressed air at a pressure of 90 lbs. per sq. in.,

automatic separating siphons are introduced, which appear to be practically efficient. Before being conducted to a motor, or distributed throughout a building of branch pipes, the compressed air flows into a pressure regulator, which reduces the pressure to a certain extent, and maintains it uniform, so that none of the slight variations in the mains may be transmitted to the motors. From the regulator the air flows through the metre, which records the amount consumed, and after passing through a heating chamber it is delivered direct to the motor. Engines of special design are employed for converting the power of the compressed air into useful work; they vary from motors for driving a sewing-machine up to engines of 100 horse-power. The air is supplied at a main pressure of from 45 to 70 lbs. per sq. in., and at the rate of 1·5 centime per cubic metre reduced to atmospheric pressure. The purposes for which the compressed air is used may be divided into three distinct classes, as follows: First, during the day, for the distribution of motive power, and for ventilation and cooling, etc.; second, at night, for the production of electricity for lighting; third, continuously during the twenty-four hours, for driving the pneumatic clocks. The first service lasts for about ten hours, from eight in the morning till six in the evening; the second from six in the evening till two in the morning in summer, and in winter from four in the afternoon till five in the morning, and in some establishments till daylight. Thus, although the conditions of supply change considerably during each day, and the demand upon the central station, except for the pneumatic clocks, is very variable, the work of the condensers and air-compressors is continuous, and the variations and requirements are sufficiently regular for determining within comparatively narrow limits the quantity of reserve power it is necessary to provide. The principal uses for which the compressed air-supply has already been employed, besides driving the pneumatic clocks, include driving pneumatic motors, for actuating all kinds of machinery, winding up the printing telegraph instruments in the Paris post-offices, shifting wine from one cask to another, raising water from the basement to the top of a house, ringing pneumatic bells, blowing whistles, emptying cesspools, ventilating and cooling rooms, working lifts, shearing metals, cutting stuffs, etc. Prof. A. C. Elliott, in a paper on the "Compound Principle in the Transmission of Power by Compressed Air" (*Engineering*, August 28, 1891, p. 238), points out that the heat dissipated in a compressed-air transmission system is a waste product, but the loss is a minimum when the compression is performed isothermally. Isothermal compression, however, has never been successfully carried out. He therefore proposes the principle of intermediate cooling, the compression being effected in two or more successive stages by a compressor with a corresponding number of properly proportioned cylinders connected by receivers, forming a mechanism analogous, as the case may be, with a compound, a triple, or a quadruple expansion steam-engine, worked, as it were, in the reverse direction. For the purposes of an example designed to show the value of the compound principle, the author has assumed the pressure of six atmospheres absolute, and made allowance for all losses, on the scale that Prof. Kennedy found them to exist in the present machinery at Paris over a distance of four miles. The efficiency of the system is taken to be the ratio of the indicated horse-power in the motor-cylinders to the indicated horse-power in the steam-cylinders of the compressor. The following were quoted in the paper as typical results:

	Efficiency.
Simple compressor and simple motor	39·1 per cent.
Compound compressor and simple motor	44·9 "
Compound compressor and compound motor	50·7 "
Triple compressor and triple motor	55·3 "

Experiments with Air-Compressors.—Prof. Riedler has made experiments with a view of increasing the efficiency of the Popp compressed air system in Paris. His results are described at some length in *Engineering*, March 13 and 20, April 10, and May 1, 1891, from which we abstract the following: "The new installation, called the Central Station of the Quai de la Gare, is laid out on a very large scale, the total generating power provided for being no less than 24,000 horse-power; of this it is intended that 8,000 horse-power will be in operation in 1891, and an extension of 10,000 horse-power in 1892. The power now in course of completion comprises four engines of 2,000 horse-power each. Four batteries of boilers will provide steam for these engines. All the principal mains and steam-pipes are made in duplicate, not only for greater security, but in order that each set of engines and boilers may be connected interchangeably without delay. The Seine supplies an ample quantity of water, but not in a condition either for feeding the boilers, for condensation, or for the air-compressors. Special provisions have therefore to be made to filter the water efficiently before it is used. The engines are vertical triple-expansion engines, and are being constructed by MM. Schneider et Cie., of Creusot, with a guarantee of coal consumption not to exceed 1·54 lb. per horse-power per hour. There are three compressing cylinders in each set of engines, one being above each steam-cylinder. Two of these are employed to compress the air to about 30 lbs. per sq. in., after which it passes into a receiver and is cooled. It is then admitted into the third or final compressing cylinder and raised to the working pressure, at which it flows into the mains." Prof. Riedler's first experiments in improving the efficiency of air-compressors were made with one of the Cockerill compressors in use at the St. Fargeau station. These compressors were designed by MM. Dubois and François, of Seraing. Two of their leading features were the delivery of the compressed air at as low a temperature as possible, and with the relatively high piston-speed of about 400 ft. a minute. The former object is attained by the injection of a very fine water-spray at each end of the water-cylinder, and

...at can be obtained from this cube metre of air delivered into a suitable motor, that ...e main point at issue, and upon which the economy of the system depends. To obtain ...hest amount of duty, M. Popp introduced the method of heating the air before allow... to pass into the motors, as has already been explained, and in many cases he has also ...d the practice of injecting a small spray of water into the air so heated. It is stated ...a number of experiments made at the St. Fargeau station of the Compressed Air Com... showed that, if the efficiency of the air before it is heated be represented by 1, this ...ency will be raised to 1·42 by heating the air to 200° C.; and if a jet of water be injected ...this heated air the efficiency will be raised to 1·90. Making a full allowance for waste ...ng from leakage, lost spaces in the motor, etc., the cube meter of air compressed to ...lbs. per sq. in. would perform useful work, equal to 578,640 foot-pounds in the cylinder ...he air motor; if heated at 200°, this efficiency would be raised to 810,000 foot-pounds, and ...h the water injection to 1,084,900 foot-pounds. As the work done in the steam-cylinder ...s 1,247,692 foot-pounds, it follows that under these last and most favorable conditions ...efficiency of the air motor would rise as high as 8·69 per cent. It is claimed that this ...ge increase in duty is secured by a very small expenditure of fuel and water, amounting ...no more per horse-power and per hour than ·44 lb. of coke and 6·6 lbs. of water. For ...all motors the air is heated by a gas-jet, as we have already explained. If the above figures ...e correct, the expense incurred for heating and water injection does not exceed one tenth ...a penny per horse-power and per hour. From the experiments made at St. Fargeau, M. ...rançois has prepared the following table:

TABLE II.—*Efficiency of Compressed Air under Different Conditions.*

	Cold air.	Heated air.	Heated and saturated air.
1. Weight of air used per indicated horse-power per hour in the cylinder of the air motor.......lb.	109·88	78·500	58·600
2. Volume of air measured at the exhaust per indicated horse-power per hour in the cylinder of the air motor.......cub. ft.	1,363	974	770
3. Temperature of compressed air delivered to the motor.......deg. C.	20	200	200
4. Temperature of air at the exhaust.......deg.	−55	......	−50
5. Percentage of efficiency	·462	·648	·869

This table shows that under the most favorable circumstances the compressed air delivered ...o a motor, even through a long length of main, will give out more than 85 per cent of the ...work that was exerted to compress it. In investigating the actual cost, M. François assumes, ...however, that in practice the duty will not exceed 80 per cent. Prof. Riedler considers ...that results as favorable as those given by compressed air can not be given by any other ...means of transmission, and for the following reasons: Power transmission of any kind ...involves several conversions, each of which is attended with a certain percentage of loss; ...these various stages are, apart from the generation of steam, a primary motor; mechanical ...appliances for the conversion of the energy of this motor into another form convenient for ...transmission; its transmission through mains, conductors, or by other means; and the re...ceiving-engine which is worked by the remnant of energy distributed from the central ...station. Allowing the smallest percentage of loss in each of these stages, a percentage which ...would certainly never be obtained in practice, it will be found that the work done by the ...second or receiving motor can not be more than 65 per cent of that developed at the central ...station. But, by using compressed air which has been heated before admission, it is claimed ...hat an efficiency of 80 per cent has been obtained under circumstances not at all favorable. ...n the trials of the "Journeaux" engines, 54 per cent efficiency is recorded, with a consump...ion of 695·7 cub. ft., although this engine, when worked by steam, for which it was designed, ...owed a loss of 25 per cent. The losses in the primary engine, in the compressors, and in ...e mains, have to be included in the difference between 54 per cent measured and the 75 per ...nt of possible efficiency due to the Journeaux engine.

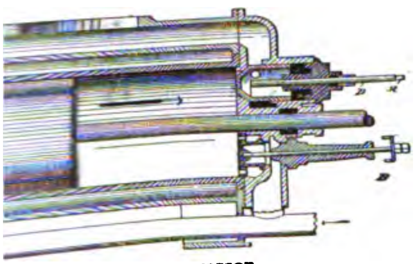
Utilization of Compressed Air in Small Motors.—The transmission of the compressed air ...ttended with loss, which increases with length of the transmission, leakage, etc. In the ...p system in Paris there has been adopted a cast-iron stove lined with fire-clay, heated ...r by a gas-jet or by a small coke-fire. The economy resulting will be seen from the ...wing table:

TABLE III.—*Efficiency of Air-heating Stoves.*

NATURE OF STOVE.	Heating surface.	Air heated per hour.	Temperature of air in oven: Admission. Deg. C.	Temperature of air in oven: Exit. Deg. C.	Value of heat absorbed per hour: Total.	Value of heat absorbed per hour: Per square foot of heating surface.	Value of heat absorbed per hour: Per pound of coke.
	Sq. ft.	Cub. ft.			Calories.	Calories.	Calories.
...box-stoves	14	20,342	7	107	17,900	1,278	2,032
	14	11,054	7	184	17,200	1,228	2,058
...iron coiled tubes	46·3	88,428	50	175	89,200	890	2,545

...esults given in this table were obtained from a large number of trials. From these ...was found that more than 70 per cent of the total number of calories in the fuel

ile the spring tries to pull it shut, and first one and then the other ispenses with the spring, the valve being opened in the usual way by



Rand compressor.

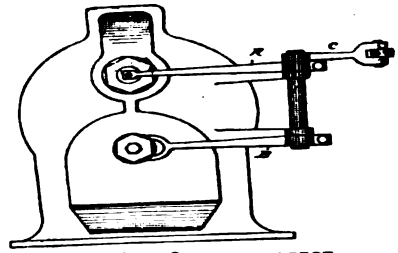


Fig. 2.—Rand compressor.

osed at the proper time—the end of the stroke—by a positive moving hanism being released when the valve is open, the valve is freed from to close it, and it hence opens to its full width and stays open. The ied, it becomes practicable to give the valve a full lift, instead of the restricted lift necessary with the usual spring-pressed valve. The increased area thus obtained cuts down the number of valves necessary for the required passageway—a single inlet and a single outlet, giving, under usual conditions, considerably more opening than the combined opening of the nest of valves previously used. The longitudinal section of the cylinder is shown in Fig. 1, from which the construction of the valves is seen, these valves being operated by levers *A* and *B*, mounted upon a common rock shaft, as shown

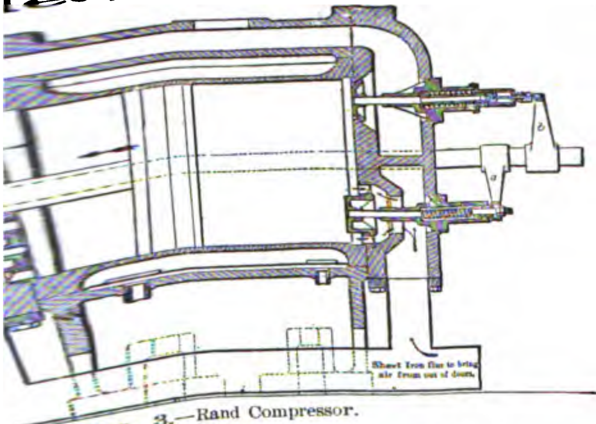


Fig. 3.—Rand Compressor.

movement of these levers toward the observer closes the suction-valves at lever *B*, while the movement from the observer closes the discharge-valve A and rod *D*. Lever *C* is connected with a corresponding lever belonging l of the cylinder by means of a link-rod, the whole system of levers being d moving to- peculiar fea- is that it ful- aried require- charge-valve, onal mechan- ie movement timed that e is at liberty er the com- compression- opening oc- the cylinder- he reservoir- er what that nor in what e the equality lished. Fig.

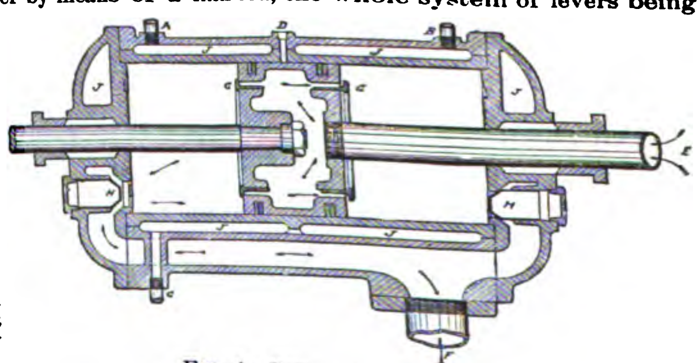
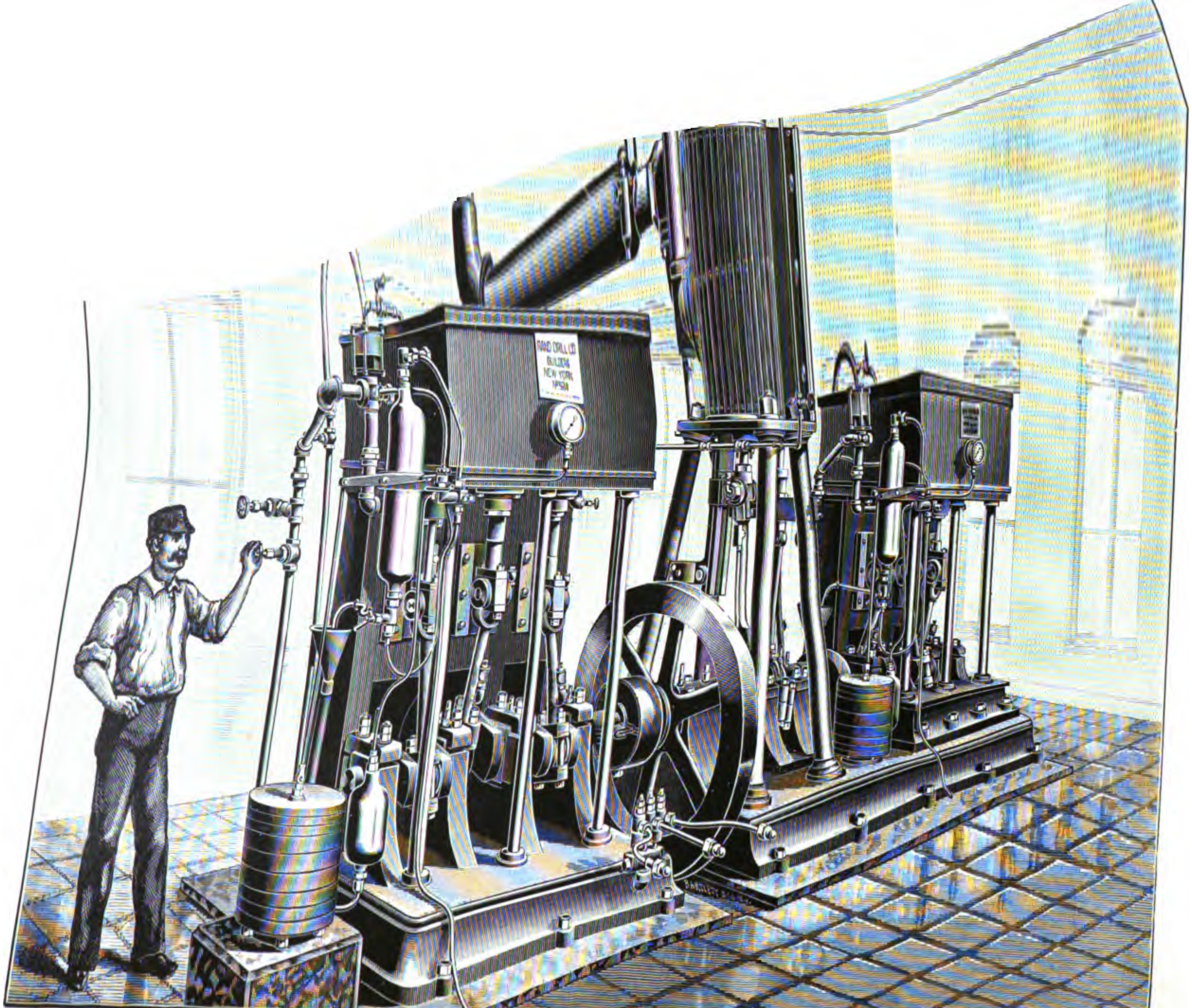


Fig. 4.—Sergeant compressor.

ther gear, of e but different principle, made by the Rand Drill Company. In this gear tained, but during the time any given valve is open the springs are pressed *a*, *b*, and their tendency to close the valves and cause chattering is thus ear has the same advantage as the last in reducing the number of valves re- area of opening. A perspective view of one of the largest Rand compress- e of the full-page plates. ncentrated *Piston Inlet Compressor* is shown in section in Fig. 4. Referring



THE RAND AIR-COMPRESSOR.

... wood; C, i... valve; D, intake cylinder; E, discharge-valve; F, intercooler; G, ...sing cylinder; H, discharge air-pipe; J, steam-cylinder; K, steam-pipe; L, exhaust ...ipe; N, swiv... connection for crosshead; O, air relief-valve, to effect easy starting

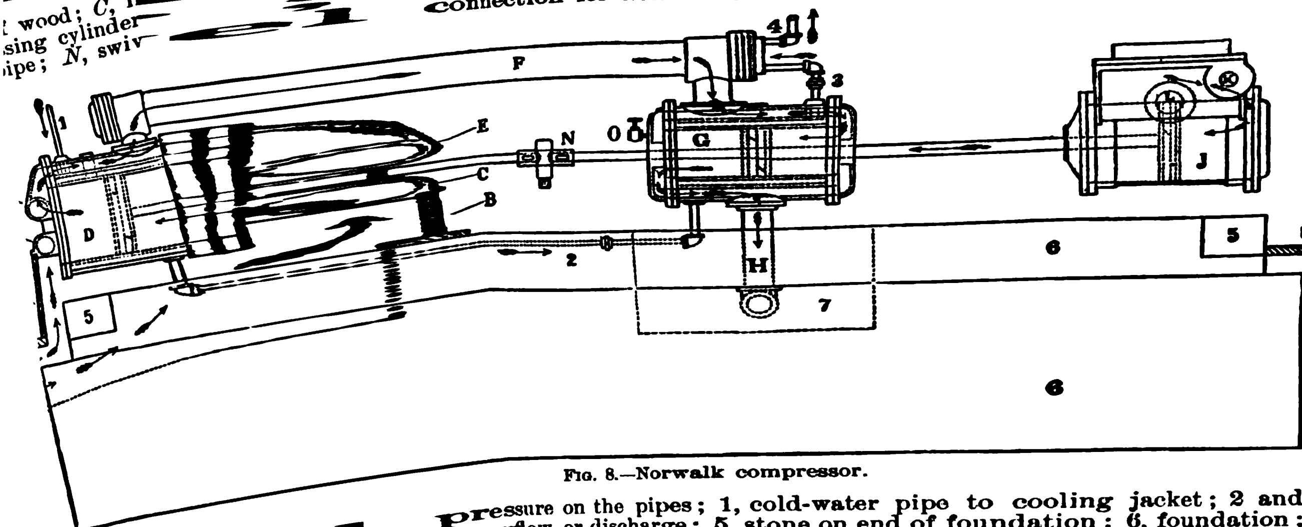


FIG. 8.—Norwalk compressor.

... pressure on the pipes; 1, cold-water pipe to cooling jacket; 2 and ... overflow or discharge; 5, stone on end of foundation; 6, foundation; ... side of cylinder; 8, floor-line. Arrows on the water-pipes show the ... tion. When pistons move as indicated by the arrow on the piston- ... in direction shown by arrows in the cylinders. The air is admitted ... of the well-known Corliss steam-engine pattern, which have a posi- ... main shaft. The port is large, is clear of obstructions, and opens di- ... The action of the forces in a compound air-compressor are described ... cylinder on the left determines the capacity of the compressor, and ... is taken at 100 sq. in. area. The small air-cylinder in the center can ... The small piston only encounters the heaviest pressure, and at 100 ... to its advance is 3,333 lbs. The resistance against the large piston ... pressure which is caused by forcing the air from the large cylinder ... which is in this case 30 lbs. per sq. in. But as this 30 lbs. pressure ... small piston and hence assists the machine. the net resistance of forc- ... into the small cylinder is equal to the difference of the area of the ... the 30 lbs. pressure. This is 66⅔ by 30 and equals 1,999 lbs. Hence ... forcing the air from the large into the smaller cylinder plus 3,333 ... smaller cylinder to compressing it to 100 lbs. is the sum of all the ... cylinders at the time of greatest effort. This is 5,333 lbs. The ... the end of the stroke, or when the engine is passing the center. ... resistance would be 10,000 lbs., hence in the compound machine ... less by over 46 per cent, or nearly one half. By thus reducing the ... of the stroke, more work is done in the first part of the stroke, ... nearly uniform for the whole stroke.

Water Injection.—The practice of injecting water into the air-cylinders of compressors is ... by American makers. The relative advantages and disadvan- ... are thus summed up by William L. Saunders, in his pamphlet on ... (1891): "Two systems are in use by which the heat of compression ... between one and the other is so distinct that air-compressors ... two classes: 1, wet compressors; 2, dry compressors. A wet com- ... introduces water directly into the air-cylinder during compression. A ... introduces no water into the air during compression. Wet com- ... into two classes: 1, those which inject water in the form of a ... compression; 2, those which use a water-piston for forcing the ... injection of water into the cylinder is usually known as the Col- ... built on this system have shown the highest isothermal results— ... finely divided spray of cold water the heat of compression has been ... the compressed air has been discharged at a temperature nearly ... admitted to the cylinder. The advantages of water injection ... follows: 1. Low temperature of air during compression. 2. In- ... per stroke, due to filling of clearance spaces with water and to a ... Low temperature of air immediately after compression, thus condens- ... air-receiver. 4. Low temperature of cylinder and valves, thus main- ... 5. Economical results, due to compression of moist air (see Table III). ... is by far the most important one, and is really the only excuse for

The percentage of work of compression which is converted into heat and loss when no cooling system is used is as follows: Compressing air to 2 atmospheres, loss 9·2 per cent; to 3, 15·0 per cent; to 4, 19·6 per cent; to 5, 21·3 per cent; to 6, 24·0 per cent; to 7, 26·0 per cent; to 8, 27·4 per cent. We see that in compressing to five atmospheres, which is the usual practice, the heat loss is 21·3 per cent, so that, if we keep down the temperature of the air during compression to the isothermal line, we save this loss. The best practice in America has brought this heat loss down to 3·6 per cent (Ingersoll injection air-compressor), while in Europe the heat loss has been reduced to 1·6 per cent. Introducing water into the air-cylinder in any other way, except in the form of a spray, has but little effect in cooling the air during compression. On the contrary, it is a most fallacious system, because it introduces all the disadvantages of water injection without its isothermal influence. Water, by mere surface contact with the air, takes up but little heat, while the air, having a chance to increase its temperature, absorbs water through the affinity of air for moisture, and thus carries over a volume of saturated hot air into the receiver and pipes, which on cooling, as it always does in transit, deposits its moisture and gives trouble through water and freezing. It is therefore of much importance to bear in mind that, unless water can be introduced during compression, to such an extent as to keep down the temperature of the air in the cylinder, it had better not be introduced at all. If too little water is introduced into an air-cylinder during compression, the result is warm, moist air; and if too much water is used, it results in a surplus of power required to move a body of water which renders no useful service. Table II (p. 20) deduced from Zahner's formula gives the quantity of water which should be injected per cubic foot of air compressed in order to keep the temperature down to 104° F. Objections to water injections are as follows: 1. Impurities in the water, which, through both mechanical and chemical action, destroy exposed metallic surfaces. 2. Wear of cylinder, piston, and other parts, due directly to the fact that water is a bad lubricant, and, as the density of water is greater than that of oil, the latter floats on the water and has no chance to lubricate the moving parts. 3. Wet air arising from insufficient quantity of water and from inefficient means of ejection. 4. Mechanical complications connected with the water-pump, and the difficulties in the way of proportioning the volume of water and its temperature to the volume, temperature, and pressure of the air. 5. Loss of power required to overcome the inertia of the water. 6. Limitations to the speed of the compressor, because of the liability to break the cylinder head-joint by water confined in the clearance spaces. 7. Absorption of air by water."

Mr. John Darlington, of England, gives the following particulars of a modern air-compressor of European type: "Engine, two vertical cylinders, steam jacketed with Meyer's expansion gear. Cylinders, 16·9 in. diameter, stroke 39·4 in.: compressor, two cylinders, diameter of piston, 23·0 in.; stroke, 39·4 in.; revolutions per minute, 30 to 40; piston-speed, 39 to 52 in. per second; capacity of cylinder per revolution, 20 cubic ft.; diameter of valves, viz., four inlet and four outlet, 5¼ in.; weight of each inlet valve, 8 lbs.; outlet, 10 lbs.; pressure of air, 4 to 5 atmospheres. The diagrams taken of the engine and compressor show that the work expended in compressing one cubic metre of air to 4·21 effective atmospheres was 38,128 lbs. According to Boyle and Mariotte's law it would be 37,534 lbs., the difference being 594 lbs., or a loss of 1·6 per cent. Or if compressed without abstraction of heat, the work expended would in that case have been 48,158. The volume of air compressed per revolution was 0·5654 cubic metre. For obtaining this measure of compressed air, the work expended was 21,557 lbs. The work done in the steam-cylinders, from indicator diagrams, is shown to have been 25,205 lbs., the useful effect being 85½ per cent of the power expended. The temperature of air on entering the cylinder was 50° F., on leaving 62° F., or an increase of 12° F. Without the water-jacket and water injection for cooling the temperature, it would have been 302° F. The water injected into the cylinders per revolution was 0·81 gallon." We have in the foregoing a remarkable isothermal result. The heat of compression is so thoroughly absorbed that the thermal loss is only 1·6 per cent.; but the loss by friction of the engine is 14·5 per cent, and the net economy of the whole system is no greater than that of the best American dry compressor, which loses about one half the theoretical loss due to heat of compression, but which makes up the difference by a low friction loss.

The wet compressor of the second class is the water-piston compressor. In America, a plunger is used instead of a piston, and as it always moves in water the result is more satisfactory. The piston, or plunger, moves horizontally in the lower part of a U-shaped cylinder. Water at all times surrounds the piston, and fills alternately the upper chambers. The free air is admitted through a valve on the side of each column and is discharged through the top. The movement of the piston causes the water to rise on one side and fall on the other. As the water falls the space is occupied by free air, which is compressed when the motion of the piston is reversed and the water column raised. The discharge-valve is so proportioned that some of the water is carried out after the air has been discharged. Hence there are no clearance losses. Hydraulic piston compressors are subject to the laws that govern piston-pumps, and are therefore limited to a piston-speed of about 100 ft. per minute. It is out of the question to run them at much higher speed than this without shock to the engine and fluctuations of air-pressure due to agitation of the water-piston. We have seen that it is possible to lose 21·3 per cent of work when compressing air to five atmospheres without any cooling arrangements. With the best compressors of the dry system about 11 per cent. of this loss is saved by water-jacket absorption, so that we are left with about one half of the loss, which the slow-moving compressor seeks to erase, but in which the friction loss alone is greater than the heat loss which is responsible for all the expense in first cost and in main-

a compressor, but which really is not saved unless water injection in the form
part of the system.

…es.—Mr. Saunders, in his pamphlet, gives the following useful tables relating
…sion of air:

TABLE I.—*Heat produced by Compression of Air.*

PRESSURE. Pounds per square inch above a vacuum.	PRESSURE. Pounds per square inch above the atmosphere (gauge pressure).	Volume in cubic feet.	Temperature of the air throughout the process.	Total increase of temperature.
			Degrees.	Degrees.
14·70	0·00	1·0000	60·0	00·0
16·17	1·47	0·9346	74·6	14·6
18·37	3·67	0·8536	94·9	34·9
22·05	7·35	0·7501	124·6	64·6
25·81	11·11	0·6724	151·8	91·8
29·40	14·70	0·6117	175·3	115·3
36·70	22·00	0·5221	218·3	158·3
44·10	29·40	0·4588	255·1	195·1
51·40	36·70	0·4113	287·8	227·8
58·80	44·10	0·3741	317·4	257·4
73·50	58·80	0·3194	369·4	309·4
88·20	73·50	0·2806	414·5	354·5
102·90	88·20	0·2516	454·5	394·5
117·60	102·90	0·2288	490·6	430·6
132·30	117·60	0·2105	523·7	463·7
147·00	132·30	0·1953	554·0	494·0
220·50	205·80	0·1465	681·0	621·0
294·00	279·30	0·1195	781·0	721·0
367·50	352·80	0·1020	864·0	804·0

TABLE II.—*Injection Water required to keep Temperature constant.*

…on by atmosphere …e a vacuum.	Heat units developed in 1 lb. free air by compression.	Weight of water to be injected at 68° F. to keep the temperature at 104° F. in pounds of water and per pound of free air.	Weight of water to be injected at 68° F. to keep the temperature at 104° F. in pounds of water for 1 cub. ft. of free air.
2	3·702	0·734	0·056
3	5·867	1·664	0·089
4	7·406	1·469	0·113
5	8·598	1·701	0·131
6	9·570	1·891	0·145
7	10·398	2·063	0·158
8	11·109	2·204	0·167
9	11·740	2·329	0·179
10	12·301	2·440	0·188
11	12·813	2·542	0·195
12	13·278	2·634	0·202
13	13·706	2·719	0·209
14	14·102	2·798	0·215
15	14·471	2·871	0·223

TABLE III.—*Showing the Relative Quantity of Work required to compress a given Volume and Weight of Air, both Dry and Moist; also Relative Volumes with and without Increase of Temperature from Compression.*

Tension in atmospheres.	COMPRESSION AT A CONSTANT TEMPERATURE. MARIOTTE'S LAW. Volume.	Work of compression. Cubic metres in kilogram-metres.	Work of compression. Cubic feet in foot-pounds.	COMPRESSION WITH INCREASE OF TEMPERATURE. Volume.	Work of compression. (Dry.) Cubic metres in kilogram-metres.	Work of compression. (Dry.) Cubic feet in foot-pounds.	Temperatures. (Dry.) Cent.	Temperatures. (Dry.) Fahr.	Ratio of greater to less temperature Absolute.	Loss of work in compressing one cubic metre in kilogram-metres. By increase of temperature alone.	Percentage of work of compression converted into heat and lost.	Final temperature if water is used in compression.	Percentage of water to air required.	FOOT-POUNDS TO COMPRESS ONE POUND AIR. Dry.	FOOT-POUNDS TO COMPRESS ONE POUND AIR. With sufficient moisture.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Deduced from 3.			Deduc'd from 6.						Fahr.			
1	1	…	…	…	…	…	20	68	1·0	…	…	68	…	…	…
2	0·5	7,199	1,468	0·61[illegible]	7,932	1,618	85·5	186	1·222	738	0·092	111	3·0	23,500	22,500
3	0·333	11,356	2,316	0·45[illegible]	13,360	2,725	130·4	267	1·375	2,004	0·150	135·5	4·0	37,000	35,000
4	0·25	14,260	2,909	0·37[illegible]	17,737	3,618	165·6	330	1·495	3,477	0·196	153·5	4·8	48,500	45,000
5	0·200	16,580	3,383	0·320	21,209	4,326	195·3	384	1·595	4,629	0·213	167	5·4	58,500	52,500
6	0·167	18,475	3,768	0·28[illegible]	24,310	4,959	220·5	429	1·681	5,835	0·240	179	6·0	67,000	60,000
7	0·143	20,038	4,087	0·25[illegible]	27,048	5,517	243·2	470	1·758	7,040	0·260	190	6·4	75,000	66,000
8	0·125	21,422	4,370	0·22[illegible]	29,518	6,021	263·6	506·5	1·828	8,096	0·274	…	…	…	…
9	0·111	…	…	0·210	…	…	282	539·6	1·891	…	…	…	…	…	…
10	0·1[illegible]	…	…	0·19[illegible]	…	…	299	570·2	1·950	…	…	…	…	…	…

AIR-HOIST. Fig. 1 shows a pneumatic hoist that has recently
Pedrick & Ayer, of Philadelphia, as a substitute for the commonly u
blocks. The cylinder is made of extra strong wrought-iron pipe, which
is carefully reamed out; to the upper head is fastened an ordinary pipe-
cap, to which there is attached a hook by which the hoists can be readily
hung to the overhead trolley, and, if desired, the hoist can be transferred
to different parts of the shop. The lower head is made of two castings
one of which is screwed to the end of the cylinder and has a lug to re
ceive a screw-end of the valve which supplies the air for lifting. B
this construction the piston can not travel below the air-opening, which
would interfere with the proper operation of the hoist. To this lowe
ring is attached a head, which is held in place by four small studs and
nuts; this head also contains the stuffing-box for packing around th
piston-rod; by this construction the lower head can be readily removed
for an examination of the piston and its packing without in any wa
disturbing the hoist. The piston is of simple-design, consisting of a
cast-iron head, follower-plate, and a leather cup-ring, which adjusts it-
self to the cylinder and prevents leakage. The lower end of the piston-
rod has a swivel, which allows the ring to be turned to any desired po-
sition in the rod. The piston acts but one way, as it has been found
that the weight of the load, or even the piston-rod and head, is sufficient
to allow it to drop when the pressure from the lower end is relieved.
The valve consists of but four parts: a body, valve-stem, cap, and small
spring to keep the valve-stem in place, which, with the air pressure, ke
stant pressure against the body. One side of the valve is provided wi
is attached to the lower ring of the hoist. The power is supplied by an
of which is 6″ to 8″ in diameter, with a storage tank of about 3′ in d
which will supply sufficient compressed air for 12 to 18 hoists havin
special purposes, such as where the hoist is used constantly, a less numbe
a compressor of the above size. Hose is attached to the upper end of the
the length of the hose depending upon the floor area which it is desired th
About 80 lbs. air pressure is generally used.

AIR-TOOL. McCoy's pneumatic tool consists of an automatic hamm
cylinder by compressed air, or by steam, which delivers a rapid success
tool-holder into which are inserted suitable bits or chisels for cutting w
It embraces in its details valves for admitting and exhausting the air, a p
the cylinder and piston from injurious friction, and for cushioning the pi
bit-socket in position, to facilitate its easy and steady application to th
applied successfully to the calking of steam-boilers, the chasing of
work, stone-dressing, and sculpture. The Committee on Science and A
Institute made a report recommending the award of a medal for thi
their report (*Journal of the Franklin Institute*, July, 1889) we extract t
tion: "As exhibited to the committee it was working at a very high s
of the sound probably more than 5,000 strokes per minute. The ins
and connected ready for action, appears in the form of a short cylinder,
centrally connected to one end, through which compressed air or st
pressure of about
centrally at the
sleeve, in which
rocates; into t
holder the cutti
mers are inserte
a latch by press
of the cylindrica
and inside of th
a working cylin
outer surface an
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upper cylinder-
ber in the outsi
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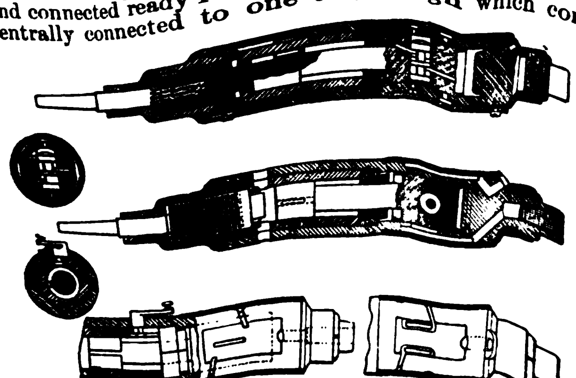


Fig. 1.—Air-tool.

der leads from reduction ports through the cylinder, external surface
the atmosphere through the head of the cylinder, and terminate
tight, but with a minimum of friction in the cylinder. The piston is
ly through it, is a piston-valve, which is worked. In the piston
the port in the side of the cylinder and exhausted by the pressure
the piston-valves of some steam-pumps, the proper through other port
uncovered by the motion of the piston. The valve ports in the cyli
grooves formed therein with a collar between them, consists of a cyli
the piston, and covers and uncovers, at proper intervals, and fits in a cylin admission

cylinder. The piston is not attached or connected to the tool-holder, as a ram or hammer; a spiral spring placed around the tool-holder, and resting with one end on a shoulder in the guide, and with the other end on a shoulder in the tool-holder, serves to retract the tool-holder; the upper end of the tool-holder has an expanded head, fitting loosely in the head of the working cylinder, and receives the blows or strokes of the piston. As the piston rises and falls in the cylinder it closes the ports and incloses a portion of the air between it and the ends of the cylinder, and thus forms an elastic cushion and relieves the operator of the shock of reversing the motion of the piston. The piston is surrounded constantly by a film of air under pressure, and, while not leaking appreciably, seems to sustain little or no wear, notwithstanding the rapid motion. The effect of the rapid and short strokes on cutting tools upon stone, wood, and metal is to produce a smoother surface than has heretofore been practicable with chisels, and with a celerity unapproached by other means. It has a capacity to reach into angles inaccessible to rotative tools." Fig. 1 shows sectional views of the machine, and Fig. 2 its adaptation as a répoussé machine.

TER. Several new alarms for steam-boilers, to give a signal when normal level, have been placed on the market within a few years. Those described below are selected to show the different principles on which they are based:

The Hardwick Automatic Low-Water Alarm, shown in Fig. 1, is explained as follows: When the water gets below the bottom of pipe *F*, the steam rushes up into copper pipe *B*, causing it to expand and raising the bell-crank *H*, blowing the whistle *A*, which will continue to blow until the surface of water *X* raises above the bottom of pipe *F*. There is an opening in lower casting *D*, shown in cut at *E*, connecting the steam space of boiler with iron pipe *C*, connecting with whistle *A*. The advantage of having two pipes and two separate openings in castings *D*, is that the copper pipe *B* having no opening at top will not draw any scum from surface of water *X*, and leaving nothing but clean dry steam in iron pipe *C*. The sounding of the whistle can be stopped by slacking the set screw in lever *H*. The same result can be attained by pouring cold water on the tube *B*, which will quickly contract the tube after the water has reached above the pipe *F*.

. 1.—Alarm.

The "Reliable" Low-Water Alarm is shown in Fig. 2. It is attached to the boiler at such height that, when the water-level has reached the lowest point which it is to fall, the float *G* will be supported so that its lever-arm is just in contact -rod which admits steam to the whistle.

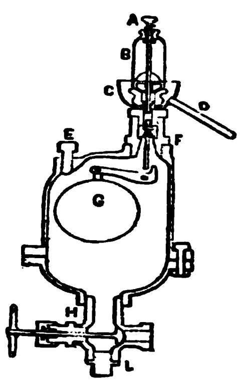


FIG. 2.—Alarm.

Prof. Thurston's researches on copper-tin and copper-zinc alloys are referred this work. His later researches, on the triple alloys of copper, tin, and zinc, en published (see Report of the U. S. Board appointed to test Iron, Steel, and , and *Trans. Am. Soc. Civ. Engrs.*, 1881). The following table is an abstract of ension made by Prof. Thurston:

Strength and Ductility of Triple Alloys of Copper, Tin, and Zinc.

PERCENTAGE OF		POUNDS STRESS PER SQUARE INCH AT		PER CENT FINAL	
Tin.	Zinc.	Elastic limit.	Ultimate resistance.	Stretch.	Contraction.
	......	11,620	19,872	0·05	10
	......	11,000	12,760	0·005	8
	......	14,400	27,800	0·065	15
10	......	15,740	26,860	0·037	13·5
20	......	......	32,980	0·004	....
30	......	5,585	5,585	......	....
33	......	688	688	......	....
43	......	2,555	2,555	......	....
61	......	2,820	2,820	......	....

Percentage of Copper.	Percentage of Tin.	Percentage of Zinc.	Pounds stress per square inch at Elastic limit.	Pounds stress per square inch at Ultimate resistance.
29	71	......	......	1,684
21	79	......	......	4,337
10	90	......	3,500	6,450
......	100	......	1,670	3,500
......	100 *	......	......	2,760
......	100 †	......	2,000	3,500
90 ‡	10 ‡	......	10,000	31,000
80	.....	20	......	33,140
62·5	.....	37·5	......	48,760
58·2	2·3	39·5	......	67,600
100	.....	.....	......	29,200
90·56	.....	9·42	......	......
81·91	.....	17·99	10,000	32,670
71·20	.....	28·54	9,000	30,510
60·94	.....	38·65	16,470	41,065
58·49	.....	41·10	27,240	50,450
49·66	.....	50·14	16,890	30,990
41·30	.....	58·12	3,727	3,727
32·94	.....	66·23	1,774	1,774
20·81	.....	77·63	9,000	9,000
10·30	.....	88·88	14,450	14,450
......	.....	100	4,050	5,400
70	8·75	20·25	18,000 (?)	31,600
57·50	21·25	21·25	1,800	1,800
45	23·75	31·25	2,196	2,196
66·25	23·75	10	3,294	3,294
58·22	2·30	39·48	30,000 (?)	66,500
10	50	40	5,000 (?)	9,300
60	10	30	21,780 (?)	21,780
65	20	15	......	3,765
70	10	20	24,000 (?)	33,140
75	5	20	12,000 (?)	34,960
80	10	10	12,000 (?)	32,830
55	0·50	44·50	22,000	66,900
60	2·50	37·50	22,000	57,400
72·50	7·50	2	11,000	32,700
77·50	12·5	10	20,000	36,000
85	12·5	2·50	12,000 (?)	34,500

* Queensland. † Banca. ‡ Gun-b

The values of the elastic limit in the lower part of the table wer

Bronzes with High Tensile Strength.—The following table gives t alloys which have recently come into extensive use. They are desc wood Garrison in *Journal of the Franklin Institute*, June and July

	Tobin bronze. 1	Tobin bronze. 2	Damascus bronze. 3	Phosphor bronze. 4	Deoxidised bronze. 5
Copper	61·20	59	77	79·70	82·67
Zinc	37·44	38·40	......	......	3·23
Tin	0·91	2·16	10·50	10	12·40
Lead	0·18	0·31	12·50	9·50	2·14
Iron	0·36	0·11	......	......	0·10
Aluminum	......	......	......	......	......
Manganese	......	......	......	......	......
Silicon	......	......	......	......	......
Arsenic	......	......	......	......	......
Phosphorus	......	......	None	0·80	0·005
	100·09	99·98	100	100	100·545

Nos. 1 and 2. Tobin bronze, claimed to have a tensile strengt elastic limit 54,250 lbs., and elongation 12 to 17 per cent with be mascus bronze, said to wear slower as a bearing metal than th No. 4. Phosphor bronze, bearing metal used by the Pa. R. R bronze. Is largely used for wood-pulp digesters, as it is found to hyposulphite and sulphurous acid. No. 6. Aluminum bronze, u Colts Fire-Arms Co. No. 7. Manganese bronze, used for propelle 000 to 43,000 lbs. elastic limit, 63,000 to 75,000 lbs. per sq. in., 1 in 5 in. When rolled the elastic limit is about 80,000 lbs. per sq. to 106,000 lbs., and elongation 12 to 15 per cent. These result manganese bronze made by B. H. Cramp & Co., of Philadelphia. in the alloy, but it may have been used as a flux in casting it. N known as Sterro metal, and practically the same as Aich's metal a tensile strength of about 45,000 lbs. per sq. in., and about 10 I rolled a tensile strength of 60,000 to 75,000 lbs., and 9 to 17 I Thurston's strongest bronze was found to have the composition : Tobin's alloy, one of the strongest of the triple alloys containe

39·5. This alloy, like the strongest bronze, is capable of being forged or rolled at a low red heat or worked cold. Rolled hot, its tenacity rose to 79,000 lbs., and when moderately and carefully rolled, to 100,000 lbs.

Silicon Bronze.—This alloy appears to have been invented about the year 1881, by M. Weiller, of Angoulême. In experimenting with phosphor-bronze wire for telegraphic and telephonic use he found its conductivity was insufficient for telegraphic purposes, so he devised the alloy now called silicon bronze. The silicon copper compound, from which the silicon bronze is produced, is made by melting, in a graphite crucible, a certain amount of copper with a mixture of fluor-silicate of potassium, produced glass, chloride of soda, carbonate of soda, and chloride calcium. It is claimed that the silicon and sodium in this mixture absorb all the oxides present in the mass. The action of the silicon on the copper is similar to that of phosphorus. It acts as deoxidizer, and the silica formed being an acid, is a valuable flux for any metallic oxides remaining unreduced. Wire made from this alloy is said to have the same resistance to rupture as phosphor-bronze wire, but with a much higher degree of electric conductivity. According to Preece, phosphorus has a most injurious influence on the electric conductivity of bronze, and silicon bronze is far superior. It also seems that, though wires made from this alloy are very much lighter than ordinary wires, they are of equal strength. According to E. Van der Ven, phosphor-bronze has about 80 per cent, silicon bronze 70 per cent., and steel 10¼ per cent of the electrical conductivity of copper.

Remarkable Aluminum Alloys.—Some recent experiments at Chalais, in France, were made on alloys of the composition given in the following table. The alloys were rolled into sheets 1 mm. thick, and strips 5 mm. in width were cut and tested:

[Al, pe]r cent.	Cu, per cent.	Sp. gr. calculated.	Sp. gr. determined.	Tensile strength in pounds per sq. in.
[illegible]0	..	[illegible]	2·67	26,535
[illegible]8	2	2·78	2·71	43,563
[illegible]	4	2·90	2·77	44,130
[illegible]	6	3·02	2·82	54,773
[illegible]	8	3·14	2·85	50,374

An interesting peculiarity of these alloys is the large divergence between the specific gravities calculated from those of their constituents and the specific gravities directly determined. Each 2 per cent of copper might be expected to raise the specific gravity by 0·12, whereas the actual observed increase is only about 0·05. It will also be observed that the addition of only 2 per cent of copper increases the tensile strength from 26,535 to 43,563 lbs. per sq. in., while 8 per cent more than doubles it. Thus it appears that an alloy of aluminum having double the tensile strength of aluminum itself can be made which is less than one twentieth heavier. The tensile strength and other properties of the Cowles aluminum bronze and brass are shown in the following table, taken from the official report of tests made under the direction of the Engineer-in-Chief of the Navy at the Watertown Arsenal:

Tests made on Specimens of Aluminum Bronze and Brass.

APPROXIMATE COMPOSITION.	Diameter.	Tensile strength per sq. in.	Elastic limit per sq. in.	Elongation in 15 ins.	Reduction of area.
	Inches.	Lbs.	Lbs.	Per cent.	Per cent.
[illegible] 91·5, Al 7·75, Si 0·75	1·875	60,700	18,000	23·20	30·70
[illegible] 88·66, Al 10, Si 1·33	1·875	66,000	27,000	8·80	7·80
[illegible] 91·5, Al 7·75, Si 0·75	1·875	67,600	24,000	13	21·62
[illegible] 90, Al 9, Si 1	1·875	72,830	33,000	2·40	5·78
[illegible]33, Zn 33·33, Al [illegible], Si 0·33	1·875	82,200	60,000 to 73,000	2·33	9·88
[illegible]92, Al 7·5, Si 0·5	1·875	59,100	19,000	15·10	3·592
[illegible]1·5, Al 7·75, Si 0·75	1·900	53,000	19,000	6·20	15·50
[illegible]0, Al 9, Si 1	1·890	69,930	33,000	1·33	3·80
[illegible]3, Zn 33·33, Al 3·33, Si 0·33	1·900	70,400	55,000	0·40	4·33
[illegible]2, Al 7·5, Si 0·5	1·930	46,550	17,000	7·80	19·19

[Mangane]se Bronze.—Mr. Garrison, in the paper above mentioned, says: "For several years manganese bronze appears to have been made in large quantities by Mr. P. M. Parsons, Manganese Bronze Company, Deptford, England. Dr. Percy was probably the first to [sugg]estion of the manganese in combining with the traces of cupreous oxide of copper, copper, deoxidizing the same, and thus making the metal denser and stronger. I believe, adds the manganese in the form of ferro-manganese. A portion of [illegible] in the alloy thus added is utilized in the deoxidation above mentioned, while together with the iron, becomes permanently combined with the copper. The [illegible] alloyed with the copper is not driven off by remelting, but usually the quality is improved by a subsequent remelting. The Manganese Bronze Company roll [illegible] alloy hot. According to Mr. Parsons, its mean tensile strength as delivered is about 67,200 lbs. per sq. in., with an elastic limit of 49,000 to 51,000 lbs. per [illegible] elongation of from 23 to 25 per cent. In cold rolling its ultimate tensile [illegible] about 90,000 lbs. per sq. in., with an elastic limit of 67,200 to 76,000 lbs. per [illegible] longation of 10 per cent. If annealed, the ultimate tensile strength is very [illegible] the elastic limit is reduced about half, and the elongation increased to 30 or

[illegible]—Messrs. Schneider & Co., of Creusot, France, have patented a process which [illegible]g in a blast-furnace, a cupola or a reverberatory furnace, castings containing [illegible] of copper with a less variable proportion of the ordinary elements. These

castings are used for the manufacture of copper steel for armor-plate, ordnance, projectiles, steam cylinders, etc., these articles being hardened or tempered in oil. The copper ore is mixed with the charge in the cupola, or else copper filings can be mixed with the coal to form a copper coke, which is then used in melting the iron in the cupola. Copper compounds may also be melted in a reverberatory furnace, with a mixture of iron or steel under a layer of anthracite to prevent oxidation. In a paper published in the *Journal of the Iron and Steel Institute*, in 1889, Messrs. E. J. Ball and Arthur Wingham describe some experiments on copper steel made by adding to a very pure basic Bessemer steel varying percentages of an alloy of iron and copper. This alloy was produced by melting pig-iron, and then adding to the molten metal oxide of copper. The carbon and silicon acted as the reducing agents for the cupric oxide, and the copper was thus introduced into the pig-iron by a "reaction," and not by simple solution. A part of the other impurities in the pig-iron was also burned out in this manner, and a metal was obtained which had the following composition:

	Per cent.
Copper	7·550
Carbon	2·720
Manganese	·290
Silicon	·036
Phosphorus	·130
Sulphur	·190

This metal was bright, white in color, crystalline, and very hard, but it did not offer any great resistance to impact. Varying quantities of it were then melted down with the basic Bessemer steel previously mentioned. The products of these fusions were allowed to cool very slowly, the crucibles in which the fusions had taken place being permitted to remain in the furnace until quite cold. Test-pieces, $1 \times \frac{1}{4} \times \frac{3}{16}$ in., were then cut, and submitted to tensile tests in a multiple lever testing machine, the test-pieces being first carefully annealed. In the alloys produced in this manner, the percentages of carbon and of copper necessarily increased simultaneously. The following table shows the percentages of copper and of carbon in the metals tested, and the results of the tensile tests of the various specimens:

TEST-PIECE NUMBER.	Copper, per cent.	Carbon, per cent.	Tensile strength, tons per sq. in.
1	0·847	0·102	18·3
2	2·124	0·217	36·6
3	3·630	0·380	47·6
4	7·171	0·712	56

The total elongation of the test-pieces was also noted, but owing to their small size the results are not trustworthy. The elongations observed, however, were as follows: Test-piece, (1) 10 per cent; (2) 5 per cent; (3) 5 per cent; (4) no visible extension, or the extension was but very slight. The tensile strength of the copper steel is greater than that of steels of like percentage of carbon which contain no copper. Copper also increases the strength of iron and of low carbon steel, as appears from the following results:

DESCRIPTION.	Copper, per cent.	Carbon, per cent.	Tensile strength, tons per sq. in.
Original steel	....	0·133	29
Test-piece 5	4·10	0·183	43·2
Test-piece 6	4·44	Trace	34·3

Mr. F. Lynwood Garrison, in his paper read before the Franklin Institute in 1891, says: "Copper-steel alloys are almost too new to determine for what particular purposes they would be most useful. It is stated in the Schneider patents that they are useful for making ordnance, armor-plate, rifle-barrels, and projectiles, and also for girders for building purposes, and ship-plates. In view of the remarkable elastic limit of copper steel, while maintaining at the same time a very considerable elongation, it would not be surprising if its use became very extensive in the arts. It has the advantage of aluminum, nickel, and tungsten steels, in being cheaper to manufacture. In many of the steel alloys, the alloying metals have to be added to the steel when they are combined with iron, which must necessarily contain some carbon—such an increase of carbon in the alloy is nearly always undesirable. Thus, for instance, if the manganese in manganese steel could be added as metallic manganese and not as ferro-manganese (which must contain carbon), we would probably obtain better results with manganese steel. The undesirable increase of carbon in this way is avoided in making copper steel, for as we have seen, the copper can be added in the metallic state, or as an ore."

Alloys for Electrical Conductors.—Mr. Edward Weston has made the remarkable discovery that the metal manganese, besides imparting a very high electrical resistance to alloys into which it enters, as a constituent, has the property of rendering the electrical resistance of such alloys nearly or quite constant under varying conditions of temperature. He therefore uses such alloys for the coils or conductors of electrical measuring instruments. He prefers to use ferro-manganese in the proportion of copper 70 parts and ferro-manganese 30 parts or thereabouts. This, however, is capable of being rolled and drawn, and is made up

NUMBER.	OBSERVER, SOURCE, ETC.	COMPOSITION. Chromium.	Combined carbon.	Graphite.	Manganese.	Silicon.	Tungsten.	PHYSICAL PROPERTIES. Tensile strength, lbs. per sq. in.	Elastic limit, lbs. per sq. in.	Elongation. Per cent.	Elongation. Inches.	Reduction of area per cent.
1	Unieux, unhardened, Brustlein	4	1·10	....	....	....	....	177,800	....	7·5	....	67·+
2	" " "	2·2	0·6	....	....	....	....	103,000	67,500	19	....	....
5	A. A. Blair and D. Smith, P.	0·45 @ 0·92	0·84 @ 1·19	0·01 @ 0·08	0·03	1·28	....	115,922	....	....	....	....
6	" " F.	0·22 @ 0·64	0·81 @ 0·99	0·01 @ 0·92	....	....	....	104,750	[illegible]	[illegible]	[illegible]	....
7	Brooklyn Adamantine, Hunt and Clapp and Howe	0·53	1·03	....	0·17	0·05	....	116,000	....	0·6	4"	....
9	Brooklyn, very hard, Hunt and Clapp and Howe	0·98	0·90	....	1·89	0·03	0·98	134,000	....	2	4"	....
9·5	A. A. Blair and D. Smith, G.	0·88	0·84	0·01	0·22	0·09	....	110,572	....	....	....	....
12	Brooklyn, Hunt and Clapp and Howe	0·29	1·32	....	0·15	0·15	0·73	124,000 / 127,000	....	6 / 9	3·5" / 3·5"	4 / 2
13	Brooklyn 1A, Hunt and Clapp and Howe	0·25	0·70	....	....	....	....	145,400	....	5·5	....	19
16	Unieux, unhardened, } same bar, Barbier, Boussingault.	....	....	....	....	....	....	108,700	85,446	15	....	50
17	" quenched from yellow,	....	....	....	....	....	....	191,000	....	1·2	....	2
18	" " " bright cherry,	....	....	....	....	....	....	202,900	....	2	....	6
19	" " " cherry,	....	....	....	....	....	....	104,260	62,306	14	....	63
20	" " " dark red,	....	....	....	....	....	....	100,000	55,000	17	....	63

into wire in the usual way. He has also discovered another alloy, the resistance of which is lowered by an increase of temperature, and he utilizes the same in making coils, etc., for such electrical instruments as should have a constant resistance under variable temperature, by making one part of the coil of said alloy and the other portion of German silver, or some other of the ordinary metals. In such case, the resultant resistance is constant, provided the change in the two parts of the coil be equal as well as opposite. This alloy preferably consists of 65 to 70 parts of copper, 25 to 30 parts of ferro-manganese, and 2½ to 10 parts of nickel.

Ferro-chrome and Chrome Steel.—M. Brustlein, of Holtzer & Co.'s steel works in the Loire, France, read a paper before the International Congress of Mines and Metallurgy, in Paris, in 1889, on ferro-chrome and chrome steel, from which we extract the following:

"There may be introduced into steel varying proportions of chromium of which the effect is to increase the resistance of steel without diminishing the tenacity corresponding to its carbon contents, and even, it appears, to slightly increase that tenacity. In consequence, it is possible to obtain, with a resistance given to the rupture, a bending corresponding to that which is obtained with a steel that is ordinarily less resisting or softer; that is to say, in describing it, as a metal which, well handled, offers a very great security. At the forge, an ingot of chrome steel may be worked with no more difficulty than with ordinary steel of the same hardness; nevertheless, when hot, it offers a greater resistance to deformation. When an ingot is cut hot by a cutter, the metal is more ductile; the point of contact between the two pieces is flattened out into a thin web before breaking. It is influenced by the fire even less than an ordinary steel of the same hardness. In the cold, when worked on a lathe or with a plane, a steel containing, for instance, 2 per cent of chromium is always a little harder to cut than ordinary steel; nevertheless, if it is properly reheated the difference is not great. Steel that contains less chromium, even when it has 1 per cent carbon, may be worked without difficulty on a lathe. Tempered with oil or with water, the temper penetrates more deeply than in a carbonized steel of the same degree of carbonization without chromium. Chrome steel offers a resistance to shock and to fracture which, for the time being, makes it preferable for a certain number of uses. On the other hand, when once made into ingots, it can be manipulated like ordinary steel, which is an additional advantage. But it offers in its manufacture difficulties of a special nature. In a state of fusion, which takes place at high temperatures, the chromium which it contains has a tendency to take up oxygen from the air. In such case there is not formed, as is the case with oxide of manganese, a liquid and fusible silicate lighter than steel, which comes rapidly to the surface, but instead there is caused the decarbonization of the steel and the oxidation of the iron, giving rise to a creamy layer, of which the little fragments rest readily, not only on the edges of the casting-pot, but even in the mass of the metal. The portions thus oxidized will not unite under any working, no matter to what temperature they may be heated. For

the same reason, the layer of oxide which is formed on heating the ingots or bars is stronger and adheres closer than in ordinary steel, and does not easily dissolve in borax. Also, chrome steel only unites with difficulty or not at all, according to the amount of chromium it contains. For these reasons chrome steel will require most delicate treatment, and it will be exceedingly difficult to use it in the manufacture of sheeting."

The accompanying table (page 26), showing analyses and physical properties of several samples of chrome steel, is abridged from a table in Howe's *Metallurgy of Steel*:

Nickel Steel.—Steel containing a small per centage of nickel has recently been found to possess the valuable property of increased tensile strength and hardness, as compared with ordinary steel of the same carbon percentage, without the decrease of ductility which in carbon steel accompanies increase of tensile strength. It has been found to be especially valuable for armor-plate, as shown by experiments made at the Annapolis proving-ground, and also in Europe in 1890 and 1891 (see *Trans. U. S. Naval Institute*, 1891). The manufacture and properties of nickel steel are thus described in a paper by Mr. James Riley, of Glasgow, published in the *Journal of the Iron and Steel Institute*, May, 1889: "The alloy can be made in any good open-hearth furnace working at a fairly good heat. The charge can be made in as short a time as an ordinary 'scrap' charge of steel—say, about 7 hours. Its working demands no extraordinary care; in fact, not so much as is required in working many other kinds of charges, the composition of the resulting steel being easily and definitely controlled. If the charge is properly worked nearly all the nickel will be found in the steel—almost none is lost in the slag, in this respect being widely different from charges of chrome steel. The steel is steady in the mold, it is more fluid and thinner than ordinary steel, it sets more rapidly, and appears to be thoroughly homogeneous. The ingots are clean and smooth in appearance on the outside, but those richest in nickel are a little more 'piped' than are ingots of ordinary mild steel. There is less liquation of the metalloids in these ingots, therefore liability to serious troubles from this cause is much reduced. Any scrap produced in the subsequent operations of hammering, rolling, shearing, etc., can be remelted in making another charge without loss of nickel. No extraordinary care is required when reheating the ingots for hammering or rolling. They will stand quite as much heat as ingots having equal contents of carbon but no nickel, except, perhaps, in the case of steel containing over 25 per cent of nickel, when the heat should be kept a little lower and more care taken in forging. If the steel has been properly made, and is of correct composition, it will hammer and roll well, whether it contains little or much nickel; but it is possible to make it of such poor quality in other respects that it will crack badly in working, as is the case with ordinary steel. In endeavoring to obtain a correct idea of the value or usefulness of alloys of nickel and iron or steel, we shall find it of use to consider their behavior under tensile and other mechanical tests, and if these were

Tests of Steel with varying Contents of Nickel.

Mark.	Composition per cent.			Tensile strength as cast.					Tensile tests as cast and annealed.					Tensile tests as rolled.					Tensile tests as rolled and annealed.					Remarks.
	Ni.	C.	Mn.	E. L.	B. S.	Extension per cent in 8 in.	Extension per cent in 4 in.	C. A.	E. L.	B. S.	Extension per cent in 8 in.	Extension per cent in 4 in.	C. A.	E. L.	B. S.	Extension per cent in 8 in.	Extension per cent in 4 in.	C. A.	E. L.	B. S.	Extension per cent in 8 in.	Extension per cent in 4 in.	C. A.	
	Per ct.	Per ct.	Per ct.	Tons.	Tons.			Per ct.	Tons.	Tons.			Per ct.	Tons.	Tons.			Per ct.	Tons.	Tons.			Per ct.	
1	1	0·42	0·58	Test-piece defective.					27·3	54·6	....	1·5	9·5	32·1	57·6	....	11	24	30·1	55·1	....	18·7	45	
2	2	0·90	0·50	Too hard to machine with musket-steel. Makes a fine tool tempered at dull red in boiling water.																				
3	3	0·35	0·57	19·8	34·9	....	2·5	5·6	24	34·9	....	2·5	9	31·4	51	....	20·8	37	28	48·5	....	20·8	42	
4	3	0·60	0·28	....	....	....	....	....	....	....	....	....	....	29·4	51·5	9	10·1	9	30·8	42·9	7·5	9	12	
5	4	0·85	0·50	Too hard to machine with musket-steel. Makes a fine tool tempered at dull red in boiling water.																				
6	4·7	0·22	0·23	....	....	....	....	....	....	....	....	....	....	25·1	40·5	17·75	23·4	42	28	40·6	20	25	44·8	
7	5	0·30	0·30	....	....	....	....	....	....	....	....	....	....	30	46·4	10	12·5	22·5	28	42·6	15	17·5	18·5	
8	5	0·50	0·84	....	....	....	....	....	....	....	....	....	....	31·1	52	14	15·6	14	32·5	46·8	18·5	14	17	
9	10	0·50	0·50	Too hard to machine. Makes a good cutting tool when tempered in cold air-blast.																				
10	25	0·27	0·35	....	....	....	....	....	....	....	....	....	....	38·2	51·4	10·5	11·7	....	12·75	45·8	29	30	29·8	
11	25	0·82	0·52	....	....	....	....	....	....	....	....	....	....	22	47·6	48·5	47·6	60	15·1	42·1	40	45·8	48·8	Average reduced by one piece, giving low result.
12	49·4	0·35	0·57	....	....	....	....	....	....	....	....	....	....	20·5	37·4	....	12	24	21	37	....	20	29	

E. L. = Elastic limit. B. S. = Breaking strain. C. A. = Contraction of area.

hardness, rigidity, and strength—constituents that will not detract from the non-corrodibility of the metal as much as do these natural impurities that come from the ore and apparatus.

Physical Properties.—Pure aluminum is white in color, with a decided bluish tint, which becomes very much more marked upon exposure, when the thin film of white oxide on its surface prevents further tarnishing from the air, but which seems to give it, by contrast to the metal as a background, an enhanced bluish tint. The addition of small percentages of silver, chromium, manganese, tungsten, or titanium changes the color of aluminum, rendering it nearer that of silver, as well as considerably increasing the hardness and stiffness of the metal. Pure aluminum has no taste or odor. Under heat, the coefficient of linear expansion of ⅛ in. round aluminum rods of 98½ per cent purity is ·0000206 per degree C., between the freezing and boiling points of water; that of iron being ·0000122; tin, ·0000217; copper, ·0000178 (authorities, Hunt, Langley, and Hall). Sound castings of aluminum can readily be made in dry sand molds, if the metal is not heated much beyond the melting-point, to prevent the absorption of gases. The metal does not need any flux. Its shrinkage is $\frac{17}{64}$ in. to the foot. The mean specific heat of aluminum from 0° to the melting-point is 0·285, water being taken as one, and the latent heat of fusion is 28·5 heat-units (authority, Richards). The coefficient of thermal conductivity of aluminum, obtained by the method of Wiederman and Franz, silver being taken as 100 and copper as 73·6, is for unannealed aluminum 37·96, for annealed aluminum 38·87. Aluminum stands fourth, being preceded only by silver, copper, and gold, as a conductor of both heat and electricity. One yard of annealed aluminum wire of 98½ per cent purity, ·0325 in. diameter, 14° C., has ·05484 of an ohm resistance, a yard of pure copper wire having a resistance of ·0315. The electrical conductivity of silver being taken at 100, copper as 90, pure annealed aluminum has an electrical conductivity of about 50. Pure aluminum has no polarity, and indeed the commercial metal in the market is practically non-magnetic. Pure aluminum is very sonorous, and its tone seems to be improved by alloying with a few per cent of silver or titanium. Pure aluminum is, when properly treated, a very malleable and ductile metal. It can readily be rolled into sheets ·0005 in. thick, or be beaten into leaf nearly as thin as gold-leaf, or be drawn into the finest wire. Pure aluminum stands third in the order of malleability, being exceeded only by gold and silver, and in the order of ductility seventh, being exceeded by gold, silver, platinum, iron, softest steel, and copper. Both its malleability and ductility are greatly impaired by the presence of the two common impurities, silicon and iron. Aluminum can be rolled or hammered cold, but the metal is most malleable at, and should be heated to, between 200° and 300° F., for rolling or breaking down from the ingot to the best advantage. Like silver and gold, aluminum has to be frequently annealed, as it hardens remarkably upon working. By reason of this phenomenon of hardening during rolling, forging, stamping, or drawing, the metal may be turned out very rigid in finished shape, so that it will answer excellently well for purposes where the annealed metal would be entirely too soft or too weak or lacking in rigidity. Especially is this true with aluminum alloyed with a few per cent of titanium, copper, or silicon. The alloys do not show their increased hardness to anything like its maximum extent in castings—not at all in proportion to the increased brittleness. But when these castings are drop-forged, rolled, hammered or drawn down, with only sufficient annealings to prevent the metal from cracking, the increased hardness appears in a remarkable degree. It can be safely stated, as a general rule, that the purer the aluminum the softer and less rigid it is. The fracture of impure aluminum shows ordinarily hexagonal crystals, although the pure metal is very tough, and on breaking, by bending backward and forward, often appears distinctly fibrous and silky in fracture.

Annealing Aluminum.—To anneal aluminum a low and even temperature should be maintained in the muffle—just such a temperature as will show an even red-heat in a piece of iron or steel placed in the muffle, when viewed at twilight or on a dark day. The aluminum itself, however, should not appear at all red at this temperature. A ready test of this is that the metal has been heated enough to char the end of a pine stick, which will leave a black mark on the plate as it is drawn across it. When the metal has acquired this temperature it should be taken from the furnace and allowed to cool gradually. Very thin sections may be annealed by placing them in boiling water, and either allowing them to cool with the water or taking them out to cool gradually. It is possible to anneal to any degree, by lowering the temperature to which the metal is heated below that specified by means of suitable appliances. Aluminum wire alloyed with a few per cent of copper, titanium, or silver, can be drawn, having a tensile strength of 80,000 lbs. to the sq. in., and which will have, weight for weight with copper wire, an electrical conductivity of 170, that of copper being 100. When it is taken into consideration that the copper has a tensile strength at a maximum of 30,000 lbs. to the sq. in., against 80,000 lbs. per sq. in. for aluminum titanium alloy, and that iron and soft steel wire have each a conductivity of 12 in the same scale, and at most a strength equal to that of the aluminum-titanium alloy, a wide field for usefulness as electrical conductors seems open for aluminum. Aluminum can be easily welded electrically, and solders satisfactorily. The specific gravity of aluminum is one of its most striking properties, it being from 2·56 to 2·70; structural steel being 2·95. copper 3·60, ordinary high brass 3·45, nickel 3·50, silver 4, lead 4·8, gold 7·7, platinum 8·6 times heavier. A cub. in. of aluminum weighs ·092 lbs., or 1½ oz. avoirdupois. Cast aluminum has about the ultimate strength of cast-iron in tension, but under compression it is comparatively weak. The following is a table of average tensile and compression strength of the metal, the average of many results of tests of the metal of 98 per cent purity:

			Pounds
Elastic limit per sq. in. in tension		(castings)	6,500
" " " "	"	(sheet)	12,000
" " " "	"	(wire)	16,000–30,000
" " " "	"	(bars)	14,000
Ultimate strength per sq. in. in tension		(castings)	15,000
" " " "	" "	(sheet)	24,000
" " " "	" "	(wire)	30,000–65,000
" " " "	" "	(bars)	28,000
Percentage of reduction of area in tension		(castings)	15 per cent
" " "	" "	(sheet)	35 "
" " "	" "	(wire)	60 "
" " "	" "	(bars)	40 "
Elastic limit per sq. in. under compression in cylinders, with length twice the diameter			3,500
Ultimate strength per sq. in. under compression in cylinders, with length twice the diameter			12,000

The modulus of elasticity of cast aluminum is about 11,000,000.

Under transverse tests pure aluminum is not very rigid. A 1 in. square bar of good cast-iron supported on knife-edges 4 ft. 6 in. long and loaded in the center will readily stand 500 lbs. without a deflection of over 2 in. A similar bar of aluminum would deflect over 2 in. with a weight of 250 lbs., although the aluminum bar would bend nearly double before breaking, while the cast-iron will ordinarily break before the deflection has gone very much beyond 2 in.

Aluminum and copper form two series of valuable alloys, the aluminum bronzes ranging from 2 to 12 per cent of aluminum with copper, the copper-hardened aluminum series with from 2 to perhaps 20 per cent of copper with the aluminum. In the 5 to 12 per cent aluminum bronzes we obtain some of the densest, finest-grained, and strongest metals known—metals having remarkable ductility as compared with tensile strength. A 10-per-cent bronze can readily and uniformly be made in forged bars, with 100,000 lbs. per sq. in. tensile strength, with 60,000 lbs. elastic limit per sq. in., and with at least 10 per cent elongation in 8 in.; and aluminum bronzes can be made to fill a specification of even 130,000 lbs. per sq. in., and 5 per cent elongation in 8 in. Such bronzes have a specific gravity of about 7·50, and are of a light-yellow color. The 5 to 7½ per cent aluminum bronzes of from 8·30 to 8 specific gravity, and a handsome yellow color, readily give 70,000 to 80,000 lbs. per sq. in. tensile strength, with over 30 per cent elongation in 8 in., and with an elastic limit of over 40,000 lbs. per sq. in. It will probably be alloys of the latter characteristics that will be most used—especially for marine work; and the fact that 5 to 7 per cent bronzes can be rolled or hammered at a red-heat, proper precautions, which can readily be secured, being taken, will greatly enlarge their use. Metal of this character can be worked in almost every way that steel can, and has the advantages of greater strength and ductility, and greater ability to withstand corrosion. The presence of silicon makes a harder bronze, but one of much less comparative ductility and a less malleable alloy. The presence of iron weakens, and very seriously interferes with the value of the bronze. The presence of zinc in aluminum bronze is not so deleterious—in fact, it makes the best aluminum brasses, much better than those having tin in them. Aluminum in bronzes lowers the melting-point of the copper at least 100° or 200°. The melting-point of 10 per cent aluminum bronze is somewhere in the neighborhood of 1,700° F. Aluminum bronze is among the hardest of the bronzes, and hardens upon cold working considerably. This hardness, however, can be lowered by annealing at a red-heat and plunging into cold water. Aluminum bronze can readily be tooled in a lathe, and the chips being cut clean and smooth and long do not clog the tool. Aluminum bronze is a remarkably rigid metal under transverse strain, being much more rigid than ordinary brass or even gun bronze; and under compression strain, although rather low in elastic limit compared with its ultimate compressive strength, it is still much stronger than any of the other bronzes. It undergoes a long period of gradual compression before it finally gives way, making it a safe metal under compressive strain. Aluminum bronze has special anti-friction qualities, owing to its fine grain texture and peculiarly smooth and unctuous though hard surface, which resists abrasion remarkably. Attention has already been called to the anti-corrosive qualities of aluminum bronze, and as its electrical conductivity is better than that of brass, it is especially well adapted for parts of electrical machinery. Aluminum bronze can be brazed and soldered nearly as well as brass. Sound, clean castings of aluminum bronze can be safely and regularly made, either in sand molds or against chills, if the proper precautions are taken to avoid: 1. Oxidation. 2. Contamination from scum, or a cinder composed of oxide of aluminum with a little copper in it. 3. Contraction cracks, caused by strains due to shrinkage. 4. The shutting in of gas into the castings. The first trouble—oxidation—can be prevented by not heating the metal too hot in the plumbago crucibles. The second trouble—contamination from scum—can be avoided by pouring into a hot ladle or pouring-basin large enough to hold all the metal necessary to fill the mold, and permitting the metal to escape from the bottom of this receptacle, after giving sufficient time to allow the scum to come to the surface. Proper skim-gates should also be provided for each mold. The third difficulty—contraction—is overcome by giving plenty of allowance of metal to feed the casting in cooling. This can be done in several ways, each best adapted for varying conditions. The cores should be made of a yield-

cter, using resin or other suitable substance, with coarse sand, that will yield under ssure. Unyielding iron metal cores should be dispensed with as far as possible. should have "risers" or "feeding-heads" with flaring openings large in section— er than the castings they are intended to feed. The feeding-heads should be refilled s they will take the metal. In this way the castings are solidified first, drawing the supply their shrinkage from the still fluid "riser," having a level higher than the tself. The gates to the mold should be of sufficient number and so arranged that be filled with metal as cold as it will pour and give full castings. The fourth diffi- s in the castings—can be prevented by taking the ordinary precautions used by for this purpose.

with Small Percentages of Copper.—The alloys of aluminum with copper in pro- of from 2 to 15 per cent have been advantageously used to harden aluminum here a more rigid metal is required than pure aluminum. Copper is the most com- l used at present to harden aluminum. A few per cent of copper decreases the of the metal, and gives alloys that are especially adapted for art castings. The of the range, from 20 per cent copper up to over 85 per cent, give crystalline and ys of no use in the arts, which are of a grayish-white color up to 80 per cent copper, listinctly yellow color of the copper begins to show itself.

um with Iron and Steel.—Aluminum combines with iron in all proportions. None s, however, have proved of value, except those of small percentages of aluminum ast-iron, and wrought-iron. So far as experiments have yet gone, other elements e employed to harden aluminum than iron, the presence of which in metallic regarded as entirely a deleterious impurity, to be avoided if possible. It has been lly proved that the addition of aluminum to the steel just before "teeming" causes lie quiet and give off no appreciable quantity of gases, producing ingots with much . There are two theories to account for this: one, that the aluminum decom- gases and absorbs the oxygen contained in them; the other is, that aluminum ses the solubility in the steel of the gases which are usually given off at the tting, thus forming blow-holes and bubbles. This latter theory is the one which the greatest weight of authority. In all cases the aluminum should be thrown after a small quantity of the steel has already entered it. There is danger of rge a quantity of aluminum, in that the metal will set very solid and will be deep "pipes" in the ingots. To add just the right proportion of aluminum little experience on the part of the steel manufacturer, but successful results red with from ¼ to ½ lbs. of aluminum to a ton of steel. If the metal be "wild" ll of occluded gases, too hot, or oxidized, a larger proportion of aluminum geously added. R. A. Hadfield says that the influence of aluminum appears of silicon, though acting more powerfully. The same writer, together with d Osmund, claims that an addition of aluminum does not lower the melting- el. Steel with an addition of one tenth of one per cent of aluminum seems he molds fully as quickly as steel without the addition of the aluminum. s to take the oxygen out of steel very much in the same way that manganese tion of aluminum in quantities of from 2 to 3 lbs. per ton is of advantage is to be cast in heavy ingots which will receive only scant work. Here it e the ductility as measured by the elongation and reduction of area of tensile ithout materially altering the ultimate strength. In steel castings the bene- of a small percentage of aluminum, ordinarily in the proportion of from 2 1, has become widely recognized, and it is being generally used. The ad- ium are most always made by throwing the metal in pieces weighing a few the ladle as the steel is pouring into it. In cast-iron, from 2 to 5 lbs. of n is put into the metal as it is being poured from the cupola or melting- gray No. 1 foundry iron it is doubtful if the metal does much good, except, ay of keeping the iron melted for a longer time; but where difficult cast- le, where much loss is occasioned by defective castings, or where the iron or give sound and strong castings, the aluminum certainly in many cases ork being done and stronger and sounder castings being made, having a ence much easier tooled. The tendency of the aluminum is to change graphitic, and it lessens the tendency of the metal to chill. Aluminum two per cent and over materially decreases the shrinkage of cast-iron. inum in wrought-iron is not very marked in the ordinary puddling o add somewhat to the strength of the iron, but the amount is not of suf- ce the general use of aluminum for this purpose. The peculiar property cing the long range of temperature between that at which wrought-iron t at which it becomes fluid, is taken advantage of in the well-known Mitis wrought-iron castings." It is for this that aluminum is most used in ent.

her Metals.—With the exception of lead, antimony, and mercury, alumi- ith all metals, and many useful alloys of aluminum with other metals within the last few years. The useful alloys of aluminum so far dis- groups, the one of aluminum with not more than 15 per cent of other of metals containing not over 15 per cent of aluminum; in the one rting hardness and other useful qualities to the aluminum, and in the iving useful qualities to the alloying metals. The addition of a few per

cent of silver to aluminum, to harden, whiten, and strengthen the metal, gives an alloy especially adaptable for many fine instruments, tools, and electrical apparatus, where work upon the tool and its convenience are of more consequence than the increased price due to the addition of the silver. The silver lowers the melting-point of the aluminum, and gives a metal susceptible of taking a good polish and making fine castings. Titanium and chromium can be readily alloyed with aluminum, according to the methods devised and patented by Prof. John W. Langley, and will probably prove to be the most valuable means of hardening aluminum. A few per cent of titanium renders the metal, under work, very rigid and elastic at the same time. Chromium is the best element to harden aluminum in castings. More or less useful alloys have been made of aluminum with zinc, bismuth, nickel, cadmium, magnesium, manganese, and tin, these alloys all being harder than pure aluminum; but it is by combination of these metals, with perhaps additions of copper, lead, and antimony, that alloys of most value have so far been discovered. Some are with additions of only 1 to 2 per cent of aluminum. The additions of from 5 to 15 per cent of aluminum to type-metal composed of 20 per cent antimony and 80 per cent lead makes a metal giving sharper castings and a much more durable type. To ordinary brass the addition of aluminum, especially in the form of aluminized zinc, an alloy of zinc with a few per cent of aluminum, gives superior strength and better anti-corrosive characteristics. Some very marked and valuable qualities have been discovered in the use of aluminum with zinc for various purposes. Additions of from ½ to 2 per cent of aluminum to Babbitt metal of a composition of copper 3·7 per cent, antimony 7·3 per cent, tin 89 per cent, gives a very superior bearing metal.

Methods of Aluminum Manufacture.—Aluminum can not be reduced from its oxide by the aid of carbon as a reducing agent by any of the ordinary methods, because the temperature to which the intimate mixture of the solid carbon and the alumina has to be raised can only be attained by the highest heat of an open-hearth furnace or in the electrical furnace—a temperature at which the alumina reduced can not itself be accumulated into a molten liquid mass, and can only be retained by collecting it with a more stable metal, such as iron or copper. None of the other salts is susceptible of being reduced by carbon at much lower temperatures than the oxide, so far as yet discovered. The task of producing aluminum at a low cost has thus been found to be a difficult one, and many unsuccessful attempts have been made and much money has been lost upon it. Debarred from using carbon as the reducing agent under the ordinary conditions which make it the practicable and economical reagent in most metallurgical operations, the advantages of other stronger reducing agents have been carefully tried. So far only one has proved commercially available, although there are other agents capable of reducing the metal from its salts. Metallic sodium reduces the metal from its chloride or from its fluoride salts readily at a red-heat. Methods based upon the use of sodium as the reducing agent have until lately given not only the purest but the cheapest aluminum. These methods, however, of late have been superseded by the cheaper and more direct processes of electrolysis of some of the aluminum salts or of the pure oxide.

History of Manufacture.—Davy, after succeeding in isolating metals of the alkaline earths, tried in vain to separate aluminum from its oxide, alumina. In 1826 Oerstedt formed aluminum chloride by passing chlorine over a mixture of alumina and charcoal heated to redness in a porcelain tube, but tried in vain to decompose this salt with sodium or potassium. In 1827 Wöhler, by better precautions to prevent oxidation, succeeded by the aid of potassium in reducing aluminum from the chloride in the form of a fine gray powder. It was very impure, and was only a metallic curiosity. In 1845 Wöhler obtained the metal in good-sized globules. Deville, twenty-seven years after the first isolation of the metal, in 1854, was the first to produce the metal in any quantity or with any degree of purity. It is curious to note that the first pure aluminum made was by electrolysis; both Bunsen and Deville reduced the double chloride of aluminum and sodium by electricity generated by galvanic batteries. Even then the idea of using electricity was old, for Sir Humphry Davy, in 1810, publicly described the successful experiment made in 1807, in which he connected the negative pole of a battery of 1,000 double plates with an iron wire which he heated to a white heat and then fused in contact with moistened alumina, the operation being performed in an atmosphere of hydrogen. The iron, upon analysis, was found to be alloyed with aluminum. Le Chatelier obtained English patent No. 1,214 in 1861, and Monckton, in 1862, English patent No. 264, for the reduction of aluminum by the aid of electricity. The Monckton patent proposes to pass an electric current through a reduction-chamber, and in this way to raise the temperature to such a point that alumina will be reduced by the carbon present, this evidently being the incipient idea of the electric furnace. Gaudin in 1869, Kagensbusch in 1872, Berthaut in 1879, and Grätzel in 1883 each brought out processes for producing aluminum by the aid of electricity. The newer pure aluminum processes using electricity, of Hall, Heroult, and the Bernard Brothers, with the help of Minet, together with the alloy processes of Cowles and Heroult, are the only ones now being worked upon a commercial scale. About 1857 the famous works at Salindres was established, under the proprietorship of Pechiney & Co., and this establishment, until within the past three years, produced a larger amount of aluminum than any other in the world. The care and skill shown and the ingenious devices and precautions taken by the firm to prevent impurities in the metal in the cumbersome and expensive sodium process in which there were so many opportunities for their addition, were worthy of the highest praise. In 1860 Sir I. Lowthian Bell started to manufacture aluminum at Newcastle-on-Tyne; the undertaking was abandoned in 1874; the sodium process was used. From 1874 until 1882 the French company at Salindres was the only concern making pure aluminum. In 1882 Webster organized the "Aluminum Crown Metal Company" at Hollywood, near

Birmingham, England, and by cheapening the production of aluminum chloride soon developed a successful concern. This was further strengthened by the improvement of H. Y. Castner, an American chemist, who in 1886 patented improvements for producing a more intimate mixture of the carbon with the caustic soda in a state of fusion by means of carbide of iron, in this way cheapening by more than one half the cost of manufacture of metallic sodium. This concern was organized under the name of the Aluminium Company, Limited, and put up a large and expensive plant at Oldbury, near Birmingham, England. These works were started at the end of June, 1888, and continued manufacturing until 1890. In common with other manufactures by the sodium process, they have been working to great disadvantage since the advent of the more successful electrolytic processes, and in 1891 ceased operations in the manufacture of aluminum. Early in 1888 the Alliance Aluminum Company started a works at Wallsend-on-Tyne, England, using a process which was an innovation upon the Deville sodium process, and employing the fluoride or the double fluoride of aluminum and sodium cryolite as the compound to be reduced instead of the chloride or the double chloride of the metal. Prof. Netto, the managing director of the concern, also has a process for producing metallic sodium cheaply, by allowing fused caustic soda to trickle over incandescent charcoal in a vertical retort. Some very excellent aluminum was produced at this works. The Hall process consists in electrolyzing alumina dissolved in a fused mixture of fluorides of aluminum and sodium, or, in fact, as Mr. Hall has described in his letters patent No. 400,766 a fused bath in which the alumina is dissolved in the fluorides of aluminum, together with the fluoride of any metal more electro-positive than aluminum. A volt-meter is attached to each pot, showing increased resistance when the ore gets out of the solvent by electrolysis, and at this time the pot-tender stirs in more ore. The feeding is thus easily made continuous, and as the fluoride solvent remains constant it only requires tapping the metal off—or, as is rather crudely but very satisfactorily done, dipping the metal out in cast-iron ladles, skimming the electrolyte back into the pots with carbon rods—to make the entire operation continuous. The cost price for the manufacture of aluminum by direct electrolysis has been brought down very low as compared with the cost of the more complicated processes of a few years ago, the items being: Two lbs. of alumina, containing 52·94 per cent aluminum. One lb. of carbon electrodes. A small expenditure for its proportionate share of the fluoride salts used for dissolving the alumina. Carbon dust, carbon pot-linings, and the metal pots. About twenty electric horse-power exerted per hour per lb. of metal made. Labor and superintendence, general expenses, interest, and repairs. As the Pittsburg Reduction Company uses the process, it places the mixture of fluoride salts, either in a solid condition or fused by the aid of external heat, in a row of carbon-lined wrought-iron tanks placed in series. The pots, together with their carbon linings and the reduced metal in the bottom of the pots, become the negative electrodes or cathodes. The positive electrodes or anodes are a series of carbon cylinders, 3 in. in diameter, attached by ⅝-in. copper rods to the copper conductors by the aid of suitable binding screw clamps. A current of large volume is turned on and the mixture, if solid, is melted by the electrically produced heat, when, in less than two hours' time, the mixture becomes fluid, and alumina is added. The electrolyte then becomes a much better conductor, "the resistance of the pot" goes down to a normal one of about eight volts, and the operation of electrolysis commences. The alumina in solution is decomposed; the metal, being heavier than the electrolyte, sinks to the bottom of the pot, and the oxygen goes to the positive electrode, uniting with a portion of the carbon and escaping as carbonic-acid gas. The Hall process can be successfully carried on entirely independent of carbon, using a thick iron or copper tank and either iron or copper electrodes. The deposition of the metal is nearly as large as with the use of carbon electrodes; but it is, of course, alloyed with copper or iron from the metal worn away from the positive electrode. The process called the "Minet process," as developed and used at the works of the Bernard Brothers at Creil, Oise, France, consists in electrolyzing a mixture of sodium chloride with the double fluoride of sodium and aluminum, their English patent dating July 18, 1887, No. 10,057. This company has been doing successful work, and is now putting aluminum of good quality on the market. In both the Cowles and Heroult processes aluminum is manufactured only in the form of an alloy. The principle involved is the interruption of a powerful electric current and the formation of an immense arc, and the reduction, at the high temperature produced by this arc, of alumina by carbon in the presence of either molten copper or iron. The Cowles furnace is a horizontal box, carbon-lined, having the current carried to it through two 6 in. round carbon cylinders, which are arranged so that they may be moved forward and back in the furnace, which is filled with broken pieces of carbon and alumina mixed with the carbon and with turnings of iron or copper. The whole of the interior of the furnace is raised to a very high temperature by the electric arc formed, and the alumina present is reduced by the carbon and alloys with the metal. In the Heroult process the electrodes are vertical instead of horizontal. The alumina is fused by the electric arc, floating on molten copper or iron, is then treated as though it were an electrolyte; the carbon rod dipping into the molten alumina being the positive pole, and the molten iron or the negative electrode, which is in contact with the negative pole of the conductor. It is probable that there is considerable electrolytic action upon the molten alumina in the furnace for the reduction of aluminum, as well as a direct reduction of the oxide by carbon. The Aluminium Industrie Actien Gesellschaft, at the Falls of the Rhine, Neuhausen, in Switzerland, claim to produce from 25 to 30 grammes of aluminum per horse-power hour, in the form of a 10-per-cent aluminum-copper bronze.

Aluminium Bronze: see Alloys. **Aluminium in Steel**: see Steel Manufacture.

Amalgamator: see **Mills, Gold**, and **Mills, Silver**.
Ambulance: see **Carriages and Wagons**.
Ammonia Machine: see **Ice-making Machine**.

ARMOR. Early in the eighties iron was still to be found as a material for the construction of the hulls of battle-ships, and compound armor was in use by all the leading powers; the complete belt and armor had not yet begun its reaction toward special gun-position protection, and deck-protecting the ends had only just become a prominent feature. The French in the Marceau and Hoche and the Russians in the Dmitri Doushoi still held to the complete water-line belt. A change in gun-protection, however, is noted in the Hoche, a sister ship of the Marceau, in which the barbette with its light shield is changed to a completely covered barbette or modified turret. Each of the four heavy guns is carried in a separate armored redoubt—an arrangement of the primary battery rather costly in weight of armor.

The Italians, in the Lauria class, revert to the partial belt, with armored decks for water-line protection, and a strong central redoubt, carrying the heavy guns in barbette. In this vessel of 11,000 tons displacement, the armor is steel, 19·7 in. in thickness, and the hull is of steel; the ends are not armored. In this same year, 1881, the English, in the *Impérieuse* and Warspite, show French influence by the battery distribution and its protection. The heavy guns are in separate positions in barbette; a heavy protective deck runs fore and aft, the midship portion being protected by a compound armored belt, 10 in. thick, about one third the length of the vessel.

The English started in this decade by building barbette ships with armored ammunition-tubes, but provided no protection immediately below the barbettes (see Fig. 1). There is a protective deck, but the armor belt for water-line defense, though thick, is very short. This typical ship, the Collingwood, was followed by five of the same class, all of which carry a secondary battery of 6-in. guns. In these vessels the armored barbettes are carried at a considerable height above the armored portion of the hull.

Fig. 1.—English type of barbette ship.

In the strength of the protective armor on the tubes and in the general protection of the loading arrangements and gun-mountings, the belting of these vessels has been considered far superior to those found in most foreign war-ships. It was decided, however, in view of the great development of high explosives, that in any new designs for barbette ships the proportion of the length at the water-line protected by the belt of armor should be greater in new vessels of this same general type; and, further, that the armored barbette towers should be carried down to the top of the belt, in order that there should be no possibility of the bursting of shells, containing large explosive charges, under the floors of the barbettes upon which the revolving gun-platforms are carried.

In 1883 the Russians, in the Tchesma, follow closely the then prevalent Italian idea of a central citadel, and have a heavily armored central redoubt. The complete water-line belt is given up, the ends being protected by a 3-in. armored deck. The six heavy guns, still in barbette, are mounted on disappearing carriages. The hull of this vessel is of iron and steel, the armor being composed of 18 in. thickness in the heaviest portions. The first Re Umberto, 13,300 tons, proposed in 1884, was the heaviest vessel designed up to that time. The heavy guns were in barbettes at either end of the vessel, being protected by steel armor 18·87 in. thick, the ammunition-tubes had 14·11 in. of armor, while the protective deck was 4·72 in. at its thickest parts, over the machinery, tapering and running to the extreme ends of the vessel. The auxiliary battery was in an unarmored casemate between the positions of the large guns.

In the Russian Alexander II the isolated armor on gun positions is reduced in thickness and spread over a larger and continuous area: the barbette is forward and protected by 10 in. of compound armor. The spur is also heavily armored; the auxiliary battery is carried in recessed ports having 6 in. of protection. In 1885 the English produced the Victoria, in which a departure was made from their former types of battle-ships. There is an armored belt amidships, 18 in. in thickness, and covering about one half the length of the vessel; then there is another belt, 6 in. thick, to protect that portion of the upper deck abaft the turret, and forming a casemate. The barbette mounts for the large guns are abandoned for a turret having 16 in. of armor, and placed on top of a supporting base also carrying armor 16 in. in thickness; a 3-in. protective deck runs fore and aft.

The Collingwood class is continued, though by vessels of a larger displacement, a somewhat superior type of battle-ship being presented by the Trafalgar and Nile in 1886. Most demands are well met in this class, but the secondary battery is somewhat weak. It was originally designed to be composed of eight 5-in. guns in broadside, without any protection, but was changed to six 4·72-in. rapid-fire guns behind 4 in. of armor. The irresistible logic of events had at this time forced the displacement above 14,000 tons; the water-line defense continued about the same. Few, if any, armored vessels with complete or partial water-line belts have these of sufficient depth to give proper protection when rolling. This defect is minimized, of course, in the large ships of from 13,000 to 15,000 tons displacement, which

roll appreciably in any sea-way that permitted ordinary vessels to work
to ... ships there was greater freeboard at the ends, four heavy guns placed high
...te ... separate barbettes, and a central battery, containing an auxiliary arma-
two ... that provided for in the turret ships. In the strength of the protective
with ... ammunition-tubes, and in the general protection of the loading arrangements

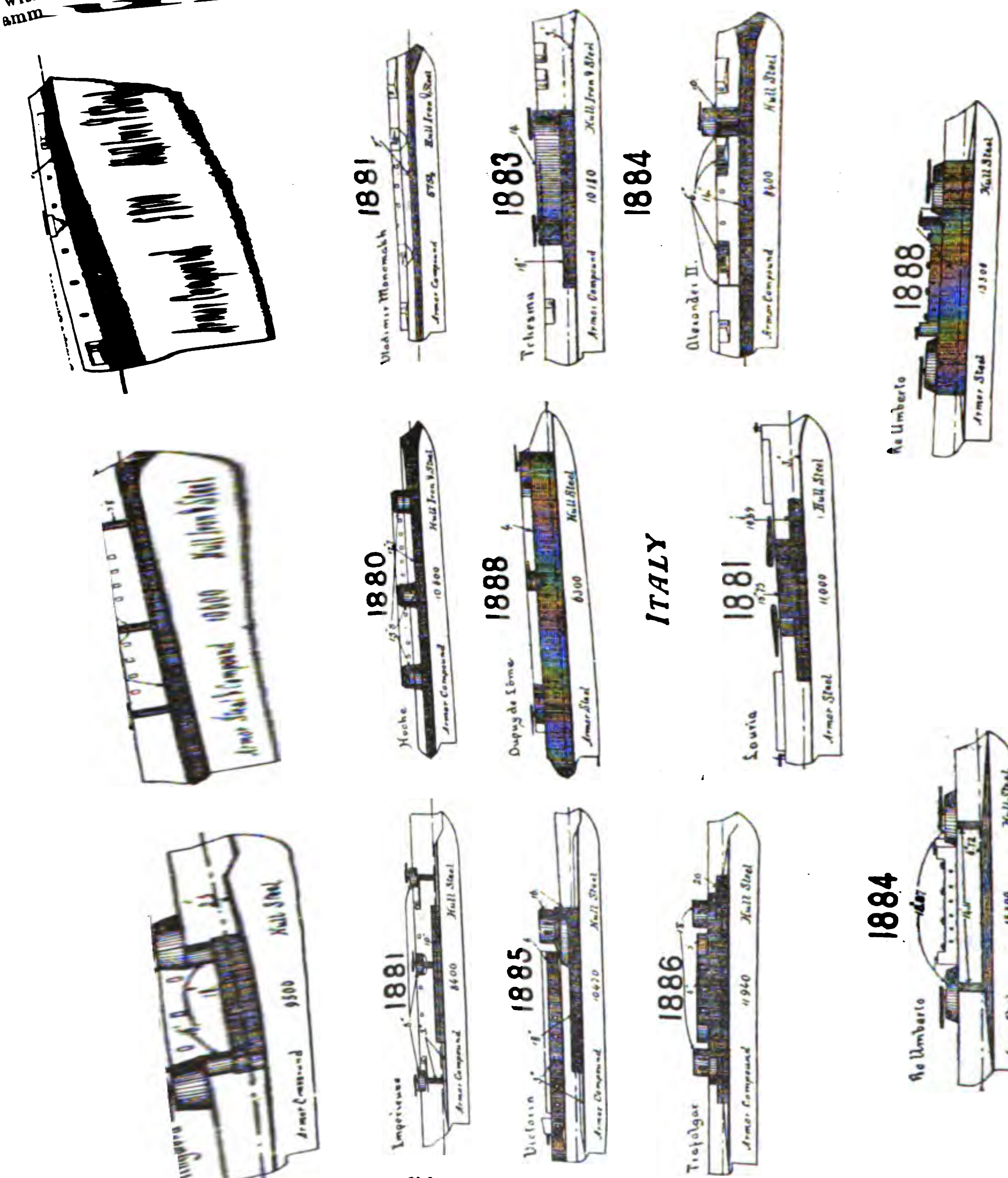
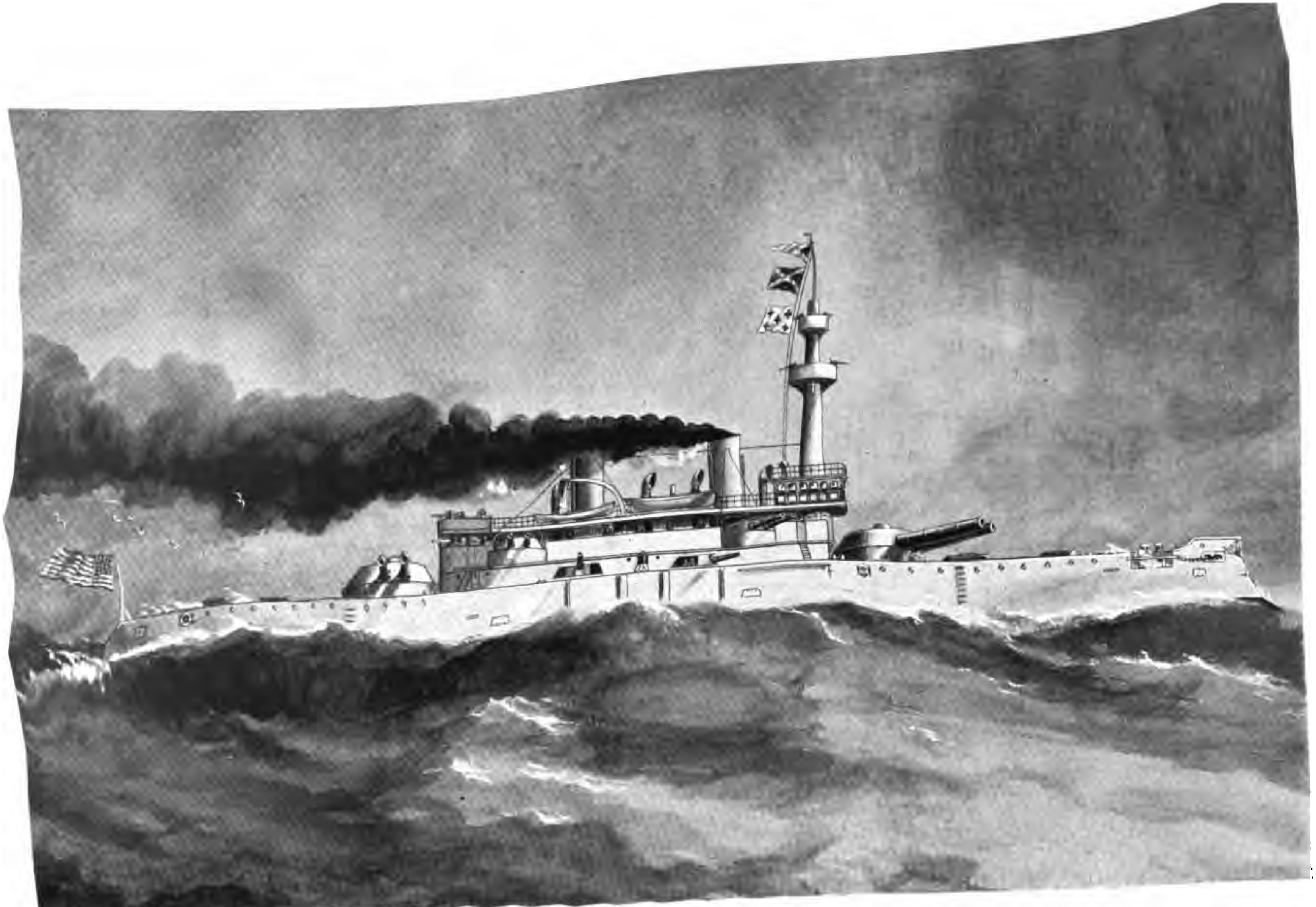


FIG. 2.—The development of English, French, Russian, and Italian armored vessels.

...tings the English type of barbette (Fig. 2) is held to be far superior to that to be
foreign war-ships. It was decided, however, in view of the great development



THE UNITED STATES ARMORED BATTLE-SHIP INDIANA.

indications of imperfect welding. Against brittle projectiles like the Palliser the compound plates acted to greatest advantage.

Of a number of English-made steel plates which were tested in 1888 but two gave results at all comparable with those obtained from the competing compound plates, a decided lack of uniformity in the metal being very apparent. A steel plate made by Vickers gave better results. The equal penetration and the very similar effects on the armor-piercing projectiles gave evidence of great homogeneity of the plate. The elasticity of the metal was well exemplified by the rebounding of the projectiles, and its comparative softness by the effect on the back of the plate. A large order from the English Government followed the satisfactory showing of the Vickers plate.

In 1888 the French fired chilled cast-iron projectiles of 83·8 lbs. against Schneider steel plates 5¼ in. thick. Each of the projectiles was broken in about the same manner, and their penetrations not being in proportion to the projectile's energies, it was concluded that the metal lacked uniformity. Later, the same year, a heavier plate, 9·6 in. thick, was fired at with chilled cast-iron projectiles weighing 99·2 lbs. with most excellent results, homogeneity of the plate being clearly demonstrated. The plate, however, greatly outmatched the projectiles. In May, 1890, a Schneider plate was again fired at, and behaved much better than in either of the preceding trials. In July of the same year plates of the same make were fired at with Finspong armor-piercing cast steel. The similar effects on plate and projectiles indicated satisfactory uniformity, and the plate was considered superior in resisting power to any Schneider plate previously tried. It also demonstrated the practicability of forming steel into curved plates without detracting from the resisting power of the metal.

We now come to what were considered the most important and conclusive armor trials ever undertaken by governmental officials. These are interesting, not only on account of the definiteness of the results obtained, but also from the fact that in each case the plate which fairly carried off the honors was neither one of the old-time rivals—English compound and Schneider steel—but was an alloy of nickel with steel. In addition, the projectiles used were so little damaged on impact that the effects on the competing plates can be fairly compared, a matter of considerable difficulty in earlier trials. The trials at Ochta are given first, as the nickel-steel plate tested there was made a year previous to that used in the Annapolis test in this country.

The trial took place at the Ochta naval battery, in Russia, and three plates were submitted. A Brown (Ellis patent) compound plate, a Schneider nickel-steel plate, and a Vickers all-steel plate, each 8 ft. square, about 10 in. thick, and 11·7 tons weight. The gun was a 6-in. 35-caliber, firing a Holtzer 89·38 lbs. Five shots were fired at each plate; the first two were not so well tempered as the remaining three. Here the Brown plate was completely outmatched; in addition to an unexpected degree of penetration, it was also badly fractured, an unusual occurrence when a compound plate of such thickness is attacked by small projectiles, but the slight scaling off of the hard steel face showed that the welding was excellent. Its performance proved that it did not merit classing with its competitors.

The Vickers plate did comparatively well, but its resisting power was far below that of the Schneider plate, this being clearly shown by the greater penetration, and by the less amount of work done on the projectiles. Being much softer than the Schneider plate, it was much less shattered. Its back was bulged out considerably by the first shot, enough to have badly bent any framing behind it. The remaining shot did not cause any great bulging at the back, but, instead, the metal was clipped out around the shot-holes. After the trial, although considerably cracked, it was removed from its backing without having the cracked parts separate. Its lack of homogeneity was shown by the difference in penetration of the last three projectiles—17·21 and 14 in., respectively—all of which remained unbroken.

The Schneider nickel-steel plate did not show up as well as was expected, cracking more than Vickers, but it proved best of all for armor protection. Only two of the projectiles got their points beyond the back of the plate. When removed from the backing, this and the compound plate had to be banded to keep their fractured parts from separating. The rebounding of the projectiles from this plate showed it to be more elastic than the all-steel, the latter acting more like good wrought iron when attacked by projectiles of excellent quality. One especially noticeable feature was the little effect of its many cracks on the penetration of succeeding projectiles. As a result of this trial, Schneider obtained a contract for 2,100 tons of armor for the Russian battle-ship Georgy Pobedonetz, and Vickers an order for 300 tons of steel plates, from 3 to 5 in. thick, for two Russian gunboats.

The first most important trials in this country were held at Annapolis in September, 1890, at which three plates were presented, one of steel and one of nickel steel, by Schneider & Co., Le Creusot, France, and one compound plate by Cammel & Co., Sheffield, England. The plates weighed about 20,800 lbs., and were arranged on chords of a circle, with the gun-pivot as the center, and the muzzle of the gun 28 ft. distant from the center of the plate toward which it was pointed. The gun used on the first day was a 6-in. breech-loading rifle, 35 calibers long. The charge used was 44¼ lbs. for each round; the striking velocity 2,075 ft. per second. The projectiles were Holtzer 6-in. armor-piercing shell, weighing 100 lbs. After four rounds had been fired at each plate, further firing was deferred until an 8-in. gun had been mounted in place of the 6-in. The charge was 85 lbs. of brown prismatic powder, the striking velocity being 1,850 ft. per second. The projectiles were Firth armor-piercing shell, weighing 210 lbs.

The compound plate was perforated by all projectiles, and its steel face was destroyed. Two of the shells passed completely through both plate and backing. Both steel plates kept

should be adopted, having reference both to its composition and mode of treatment. The series of tests already referred to resulted in the decision to adopt nickel steel. It remained, however, to give a thorough trial to the first armor of domestic manufacture before beginning to place it upon the vessels, and for this purpose it was decided to order typical plates to test (1) whether our domestic manufacturers could produce an armor that would stand competition with foreign material, and (2) which of the various modes of treatment would give the best results.

Six plates were furnished and set up at Indian Head (1891), and they were subjected to tests more severe than had ever been applied to foreign government trials. Four shots were fired at each plate with a 6-in. gun, with an impact velocity of 2,075 ft. per second, using the Holtzer projectile of 100 lbs. One shot was then fired at the center of each plate from an 8-in. gun, with an impact of 4,988 foot-tons, or 2,000 in excess of the 6-in., using Firminy and Carpenter projectiles of 210 and 250 lbs. weight, respectively, the plates being normal to the line of fire. Three of the plates were furnished by the Bethlehem Iron Co. and three by Carnegie, Phipps & Co., some being rolled, others forged, and several being treated by the Harvey process.

The results of the trial were in the highest degree satisfactory. Each of the six plates manufactured in this country was superior to the English compound plate, while the nickel Harveyed plate and the high-carbon nickel plate were superior to all the foreign plates of the Annapolis trial. They may, therefore, be pronounced in advance of the best armor hitherto manufactured in Europe. Further light was thrown upon the question of the relative merits of all-steel and nickel-steel armor, and any doubt which may have remained upon that subject was finally set at rest. Of the three plates made at Bethlehem two were of nickel steel, one treated by the Harvey process, the other not, and the third was of all steel, Harveyed. Both the nickel plates proved to be far superior to the all-steel Harveyed plate, notwithstanding the advantages which it may have derived from the special treatment; and both proved superior to the French all-steel plate tried at Annapolis. A third nickel plate, manufactured by Carnegie, under the rolling process, also showed a marked superiority over the all-steel plate of this year, and both it and the corresponding Bethlehem plate manufactured under the hammer showed a capacity of resistance to perforation fully 10 per cent greater than that of the French all-steel plate. In this respect the results furnished by the two American plates manufactured by the different processes (forging and rolling) proved to be remarkably uniform, the 6-in. shots that were fired at them differing in penetration but an inappreciable amount. The trial thus definitely establishes the fact that armor of excellent quality may be produced by the rolling process, and that forging by means of the hammer, the greatest source hitherto of expense in manufacture, is no longer to be regarded as an absolute necessity. The importance of this fact can hardly be overestimated, for it raises a probability that within a year or two the armor-producing capacity of the United States may be quadrupled in case of necessity, and that if we had 10,000 tons to let, and could give eighteen months from date of contract to commence delivery, the cost of manufacture would be reduced from 25 to 33 per cent, while the work hitherto confined to two firms would be thrown open to a large number of competitors. Finally, the trial shows that the high-carbon nickel Harveyed plate is undoubtedly the best armor-plate ever subjected to ballistic test.

As a result of these trials orders have been placed with the firms mentioned for armor sufficient to cover the battle-ships, monitors, and armored cruisers now in course of construction in this country, and foreign governments that had not already ordered armor for new vessels have quite generally adopted the newer type. Other experiments are in progress to still further develop the qualities of nickel steel, as well as the process by which additional hardness is given to its surface.

The most powerful armored vessels of the United States at present (1892) being built are the Indiana (see full-page plate), the Massachusetts, and the Oregon. Each of these vessels has a water-line armor-belt 7½ ft. wide and 18 in. thick. Armored redoubts 17 in. thick at each end of the belt extend 3¼ ft. above the main deck, and thus give an armored free-board of 15 ft. 2 in. These redoubts protect the turning-gear of the turrets, and all operations of loading. The turrets have 17-in. inclined armor. The 8-in. guns have barbettes of 10 in., inclined turrets of 8½ in., and loading tubes of 3 in. The side armor is backed by 6 in. of wood, two ¾ in. plates, and a 10-ft. belt of coal. Above the belt armor the side is protected by 5 in. of steel. The protective deck is from 2¾ to 3 in. thick.

It is not alone to ships that armor is being applied; its use has been extended to the protection of guns on shore, particularly by France and Germany. Of late years great revolutions have taken place in the principles upon which such forts are constructed, and in the Gruson system is seen one of the most approved types of armored fortifications. In this system the conditions kept in view are that the protection must insure the most perfect freedom of action to the gun; the necessary men must be kept as low as possible, the construction must be light and easily movable, and there must be the utmost reduction of the interior space.

The Canet system differs in details from the above, although the conditions to be fulfilled are practically the same. In both there is heavy armor, for offering an efficient resistance to heavy projectiles, even when charged with melinite or other high explosive, sufficiently heavy not to be injured by the recoil energy set up by the firing of the guns. The latter are to be as far as possible independent of the turrets, and are mounted upon disappearing carriages, so that their crews are protected during the operation of loading. The plan is circular, and a masonry-lined pit is sunk as a basement for the gun-platform. A shield of steel or wrought

Barrel, Chlorinating: see Mills, Gold.

BARREL-MAKING MACHINES. In the manufacture of both tight and slack barrels, and more especially in the latter, machinery is used to an extent which is increasing year by year; and the indications are that even in tight barrel-making, at least where the barrels are not to contain very expensive liquids, hand-work will be superseded by better and cheaper work done by machinery. In this line there are but few manufacturers, and among these not more than one or two who make a full line, enabling a cooperage establishment to be started with facilities for making every part of every kind of a barrel, to be both made and put together by machinery. From the multiplicity of machines for making parts of barrels or for assembling them into complete wholes, ready for shipment, we can make but a limited selection.

Stave-Jointer.—In the ordinary stave-jointer there is employed a knife at least as long as the stave is to be, and having its edge ground to a double slope—that is, the blade has a straight back, but is widest in the middle, its edge being composed of two straight lines meeting at an obtuse angle. This gives a draw cut both ways from the center. The knife is also bent to a degree corresponding to the amount of bilge; and the shook being clamped in place, the knife, which slides guillotine-like, is brought down by foot-power and returned by springs.

Lock-Cutter.—The power lock-cutter is used for cutting locks on wood barrel-hoops of different lengths and widths in their proper position, without changing the machine for hoops of different sizes, and chamfering the ends of the hoops. There is a rotary cutter-head bearing cutters which are nearly straight on their edges. This cutter-head is so formed that the hoop can be and is pressed against it without danger of drawing the hoop into it. The clamp that holds the hoop while being cut is adjustable horizontally and vertically, giving capacity for changing the form of the lock and of the hook.

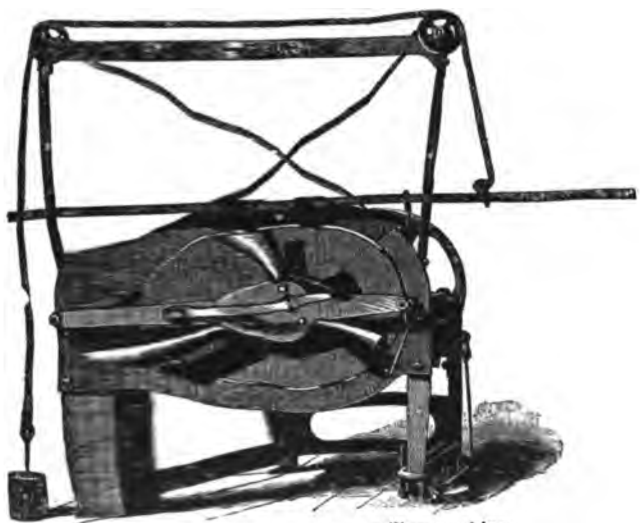


Fig. 1.—Hoop-coiling machine.

An Automatic Hoop-Coiling Machine is shown in Fig. 1. This serves for coiling slack barrel and keg hoops of various sizes and lengths. There is a circular head about which the hoops are coiled, which is driven by an internal friction gear attached to the back end of the head spindle, and is operated by a tarboard friction-pulley running in lever-boxes, and which are connected to a foot-lever. One end of the hoop to be coiled is inserted in an open slot in the rotating head while the machine is in motion, firmly securing the end of the hoop to the head while coiling around the disk. Each succeeding hoop is fed into the machine at the proper time to allow the preceding loop to form a lap. A steel spring is used in binding the coil firmly together. The end of the last hoop is secured to the coil by a single nail. The cone-shaped rollers shown in the figure in front of the face-plate serve as guides in keeping the hoops snug against the face-plate. These rollers are attached to a sliding carriage which has an adjustable weight for giving proper tension to the rollers from the face-plate. A three-armed spider back of the face-plate, with the arms projecting through it, slides in a horizontal plane with the rolls. After the coil is finished the weight of the operator's foot upon the lever simultaneously carries the rolls and the spider forward enough to have the coil clear the disk, when the coil is automatically discharged from the machine without stopping. The capacity of the machine is from 1,500 to 1,800 hoops per hour.

A Compound Hoop-Guide and Wood Hoop-Driving Machine, in process of manufacture, is formed by coned sections attached to and controlled by slides and springs, and moves in and out by turning a hand-wheel. It is used in connection with the hoop-driving machine of the same firm, which is driven by a combination of friction and screw power, which moves the driving arms and drivers up and down, the upward motion being more rapid than the downward, and the sectional drivers which move the hoop nearly surround the barrel, being circular in form. In using this machine in connection with the hoop-guide, the guide is placed on the head of the barrel, and a hand-wheel is turned, which moves out the cone sections a little beyond the edge of the end of the barrel. The wood hoops are then placed on the cone, and the hoop-drivers receive them and drive them to their proper position. In driving the small hoops, the cone-sections recede to the size of the hoop and guide it on to the barrel. Both the hoop-guide and the hoop-driver are adjustable for different sized barrels. This machine and the guide fill a place in the line of labor-saving machines for making wood-bound barrels for liquors.

Basic Process: see Steel Manufacture.

Bean Harvester: see Harvesting Machines, Grain.

BEARINGS. Roller and Ball Bearings.—The use of rollers and balls in bearings for the purpose of converting sliding into rolling friction is meeting with success in numerous

that will show what power a good belt *may* transmit under given conditions, they can not be implicitly relied upon to show how much power a particular belt *does* transmit."

An elaborate set of experiments on belts was made in 1885 by William Sellers & Co., and reported by Mr. Wilfred Lewis (*Trans. A. S. M. E.*, vol. vii, p. 549). These experiments seemed to show that the principal resistance to straight belts was journal-friction, except at very high speeds, when the resistance of the air began to be felt. The resistance from stiffness of belt was not apparent, and no marked difference could be detected in the power required to run a wide double belt or a narrow light one for the same tension at moderate speeds. With crossed and quarter-twist belts, the friction of the belt upon itself or upon the pulley in leaving it was frequently an item of more importance, as was shown by special experiments for that purpose. The experiments also showed that, in all probability, leather is more elastic under light tensions than it is under high ones. A piece of belting 1 sq. in. in section and 92 in. long was found by experiment to elongate ¼ in. when the load was increased from 100 to 150 lbs., and only ⅛ in. when the load was increased from 450 to 500 lbs. The total elongation from 50 to 500 lbs. was $1\frac{1}{16}$ in., but this would vary with the time of suspension, and the measurements here given were taken as soon as possible after applying the loads. In all cases the coefficient of friction was shown to increase with the percentage of slip. An interesting feature of these experiments is the progressive increase in the sum of the belt tensions during an increase in load. *This* is contrary to the generally accepted theory that the sum of the tensions is constant. *The* highest coefficient obtained was 1·67, but, of course, this was temporary. The diameter of the pulley also appears to affect the coefficient of friction to some extent. This is *especially* to be noticed at the very slow speed of 18 revolutions per minute on 10-in. and 20-in. pulleys, where the adhesion on the 20-in. pulleys is decidedly greater; but, on the other hand, at 160 revolutions per minute, the adhesion on the 10-in. pulleys is often as good as, and *sometimes* better than, appears for the 20 in. at the same velocity of sliding. It might be possible to determine the effect of pulley diameter upon adhesions for a perfectly dry belt, where the condition of its surface remains uniform; but for belts as ordinarily used it would be very difficult, on account of the ever-changing condition of surface produced by slip and temperature. It is generally admitted that the larger the diameter the greater the adhesion for any given tension, but no definite relation has ever been established, nor, indeed, does it seem possible to do so, except by the most elaborate and extensive experiments. Theoretical formulæ hitherto used in calculations of belt-power have assumed the coefficient of friction as uniform around the arc of contact, but this can no longer be correct if the coefficient varies with the pressure. Mr. Lewis says the driving-power of a leather belt depends upon such a variety of conditions that it would be manifestly impracticable, if not impossible, to correlate them all; and it is thought better to admit the difficulties at once than to involve the subject in a labyrinth of formulæ which life is too short to solve. Mr. Lewis estimates that under good working conditions the efficiency of belt transmission may be assumed to be 97 per cent. When a belt is too tight there is a constant waste in journal-friction, and when too loose there may be a much greater loss in efficiency from slip. The indications and conclusions drawn from his experiments are as follows: 1. That the coefficient of friction may vary under practical working conditions from 25 to 100 per cent. 2. That its value depends upon the nature and condition of the leather, the velocity of sliding, temperature, and pressure. 3. That an excessive amount of slip has a tendency to become greater and greater, until the belt finally leaves the pulley. 4. That a belt will seldom remain upon the pulley when the slip exceeds 20 per cent. 5. That excessive slipping dries out the leather, and leads toward the condition of minimum adhesion. 6. That rawhide has much greater adhesion than tanned leather, giving a coefficient of 100 per cent, at the moderate slip of 5 ft. per minute. 7. That a velocity of sliding equal to ·01 of the belt-speed is not excessive. 8. That the coefficients in general use are rather below the average results obtained. 9. That, when suddenly forced to slip, the coefficient of friction becomes momentarily very high, but that it gradually decreases as the slip continues. 10. That the sum of the tensions is not constant, but increases with the load to the maximum extent of about 33 per cent with vertical belts. 11. That, with horizontal belts, the sum of the tensions may increase indefinitely as far as the breaking strength of the belt. 12. That the economy of belt transmission depends principally upon journal-friction and slip. 13. That it is important on this account to make the belt-speed as *high as* possible within the limits of 5,000 or 6,000 ft. per minute. 14. That quarter-twist belts should be avoided. 15. That it is preferable in all cases, from considerations of economy in wear on belt and power consumed, to use an intermediate guide-pulley, so placed that the belt may be run in either direction. 16. That the introduction of guide and carrying pulleys adds to the internal resistances an amount proportional to the friction of their journals. 17. That there is still need of more light on the subject.

Mr. Samuel Webber (*Trans. A. S. M. E.*, vol. viii, p. 537) proposes the following formulæ for leather belting, where the tension with which the belt is put on is known or assumed:

$$\text{Width in inches} = \frac{\text{No. HP.} \times 33{,}000 \times 180^\circ}{\text{velocity in ft. per minute} \times \text{strain in lbs. per in. width} \times \text{arc of contact}}$$

and

$$\text{HP.} = \frac{\text{velocity in ft.} \times \text{strain per in.} \times \text{width} \times \text{arc of contact}}{33{,}000 \times 180^\circ}.$$

Mr. Scott A. Smith (*Trans. A. S. M. E.*, vol. x, p. 765) gives it as his opinion that the best belts are made from all oak-tanned leather, and curried with the use of cod-oil and tallow, all

not follow and adhere to it, as in the case of leather. The motion is, therefore, quite steady and uniform.

Bristol's Steel Belt Lacing.—Fig. 2 shows a belt fastening made by punching and bending sheet-steel into the form shown. The cut represents the lacing ready for application, and also shows a finished joint. The lacing consists of a continuous zigzag strip of steel, so proportioned as to give maximum strength with a minimum amount of material. The wedge-shaped points when driven through the belt force the fibers aside without cutting them; hence the ends of the belt are not weakened, as when holes are punched. Bristol's steel lacing, for single-thickness belting, is made in lengths from 1 to 3 in.; for belts wider than 3 in., two or more lacings are used.

FIG. 2.—Steel belt lacing.

Wire Belting.—A belt made of steel wire woven into a flexible web and covered with rubber is made by the Midgely Wire Belt Company, Beaver Falls, Pa. It is claimed to be nine times as strong as a leather belt, and more flexible.

Leather-Link Belts.—The construction of leather-link belts is shown in Figs. 3 and 4. They consist of small pieces of leather of the oblong shapes shown in Fig. 4, with holes near the ends, by which they are connected. These belts are valuable for a variety of purposes, and especially for damp places. They are water-proof, there being no cemented joints to give way by contact with dampness. By virtue of their weight they are capable of transmitting a considerable amount of power without great width of belt and pulleys. When made with a center-hinge joint they fit laterally to the pulley

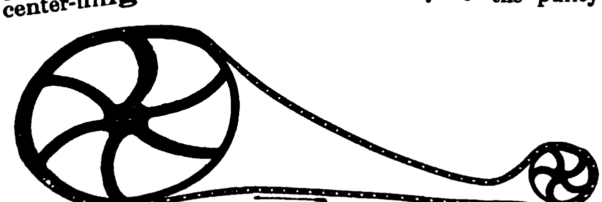


FIG. 3.—Leather-link belt.

FIG. 4.—Leather-link belt.

more completely than solid leather belts, and this quality assists them in the transmission of power. The proper manner of running a link-belt is illustrated in Fig. 3. Here the belt is drawn taut upon the under side, allowing the upper side to sag and climb the driven pulley, so as to bring the belt in contact with a large proportion of its circumference. This large arc of circumference in contact, and the weight of the belt, result in the largest possible amount of power transmitted. Fig. 5 represents a cross-section of the Acme Link-belt, the dotted lines showing the three bolts by which the links are held together transversely; the three center links, placed upon the highest part of the pulley, as shown, are made V-shaped

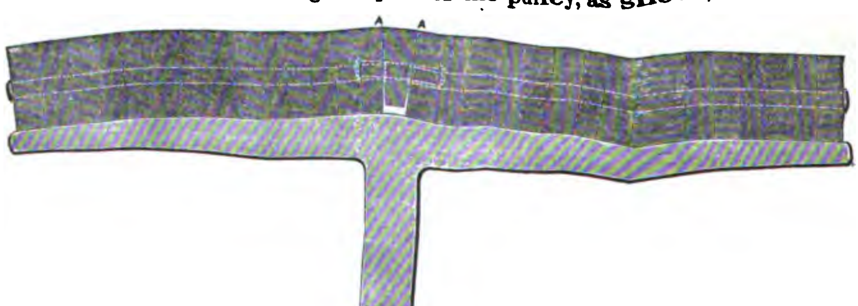


FIG. 5.—Link-belt.

These form the center hinge, giving flexibility and adjustability to the belt. At the lines A A are shown the heads of the two bolts, which extend from this hinge-joint to the outer edge of the belt.

Iron-Link Belts.—Detachable malleable iron links are largely used in bulk-elevating and conveying, and in the transmission of power under suitable conditions. The sizes in common use are designated by numbers—the first or first two figures giving approximately the diameter in sixteenths of an inch of the end and side bars of the link, the final figure indicating the sequence of the link among those of like strength; thus, No. 44 has side and end bars $\frac{4}{16}$ in. in

several ropes to pull against each other, and throwing the strain of the transmission on less
than the whole number of ropes. Nothing has so militated against the general employment
of rope driving in this country as the use of imperfect multiple grooved sheaves, those con-
structed of wood having proved specially faulty. The unequal density of wood permits un-
equal wear of grooves, and the sheave soon becomes of differential diameters. The rope gen-
erally employed in this country is manilla. Cotton is largely used in England for transmis-
sion work, but has not seemed to meet special favor here. Manilla transmission rope should
be of long fiber, and be laid in tallow, to reduce the fiber friction caused by the bending of
the strands in passing round the sheaves. Such rope tests about as below:

Diameter.	Breaking strain.	Diameter.	Breaking strain.
$\frac{5}{8}$ in.	4,000 lbs.	$1\frac{1}{8}$ in.	12,000 lbs.
$\frac{3}{4}$ in.	5,000 "	$1\frac{1}{4}$ in.	14,000 "
$\frac{7}{8}$ in.	7,400 "	$1\frac{3}{8}$ in.	18,000 "
1 in.	9,000 "	$1\frac{1}{2}$ in.	20,200 "

The above table is based on tests of best long-fiber pure manilla, made specially for trans-
mission purposes. The best practice employs in rope driving but 3 per cent of the ultimate
strength, though as high as 6 per cent is figured when conditions are exceptionally favorable.
A large margin of safety is required to provide against imperfect splicing.
The tension device—necessary where the continuous wrap system is employed—consists of
a movable tension-carriage traveling in suitably constructed ways and carrying an idler
sheave, the tension required by the traveling ropes being given by a suspended weight conven-
iently attached to the carriage. The rope having been wrapped round the driving and
driven sheaves the proper number of times for the required driving force, the last strand on
the slack side should pass over the tension-wheel (which is deflected to lead the two ends of
the rope together), and should not become a direct driving strand until it has passed over the
driven wheel. Before reaching the driven wheel this strand may have to pass over idlers or
over a groove in the driven wheel itself, but in such cases the groove receiving it should be
loose, that the sag may be quickly taken up. As large an amount of the rope as possible
should be under the direct influence of the tension-carriage. From 18 to 25 per cent is de-
sirable, though as low as 5 per cent has been found sufficient under certain conditions. The
number of driving sheaves over which the rope passes enters into the problem as well as the
length of the rope itself. Where the rope passes over four or five sheaves (as in transmitting
power to several floors of a building) it is often desirable to employ more than one tension-
carriage. The best practice is to use one for every 1,200 ft. of rope, and put not less than 10
per cent of the rope under direct influence of the tension. In direct drives the number of feet
of rope may be slightly increased.
The speed of a transmission rope should not exceed 5,000 ft. per minute, as from this point
centrifugal force gains so rapidly on the power derived from the increased rope speed that at
about 5,500 ft. per minute the power will begin decreasing in the same proportion as its pre-
vious rise. Taking C, centrifugal force in lbs.; G, gravity; W, weight of rope per running
foot; S, speed of rope in ft. per second, the centrifugal force may be found as follows:

$$C = \frac{W \times S^2}{G}.$$

The wear of rope increases in proportion to the increase of speed; consequently, a velocity
of from 2,500 to 3,500 ft. per minute is most efficient and economical. On the size of the
sheaves employed depends very directly the life and efficiency of a rope transmission. The
diameters should never be less than thirty times the diameter of the rope, and best results are
obtained when the sheaves and idlers on the driving side are forty times, and those on the
loose side thirty times, the rope diameter. With smaller sheaves the internal friction of the
rope fibers is considerable, naturally increasing the wear, and the rope itself, through its stiff-
ness, can not hug the sheaves closely, thus increasing the loss of power due to centrifugal
force. Idlers used merely to support a long horizontal span may, if not too far apart, be as
small as eighteen diameters without perceptibly injuring the rope. This exception to the
rule given above is based on practice, however, and is not theoretically correct. The coeffi-
cient of friction of a rope in a 45° grooved sheave has been considered as variable, but several
tests recently made where the power transmitted was determined accurately by brake-test,
and, all conditions taken into consideration, showed this coefficient to vary only from ·33 to
·25. Fig. 7 represents a rope drive recently constructed. The number of wraps of rope de-
pend on the power to be transmitted, are laid in the sheaves of pulleys a and b. The rope
is led from the last sheave on driven pulley b, to and over the "idlers" k and l, to the first
sheave on engine pulley a. The "idler" l is the tension-carriage. The best practice wraps
on the rope so that the neighboring ropes are half the length of the rope apart. This is
accomplished by starting from the second sheave on a to second sheave on b, thence to fourth
on a, etc.; from the last sheave on b to the idlers and back to first sheave on a, continuing to
fill the vacant sheaves to starting-point, where a long splice is made. Fig. 7 shows the method
of taking off power at an angle.
C. W. Hunt (*Trans. A. S. M. E.*, vol. xii) gives a calculation of the horse-power of rope
drives, from which the following is condensed: C = circumference of rope in inches. D =
sag of the rope in inches. F = centrifugal force in pounds. g = gravity. H = horse-
power. L = distance between pulleys in feet. P = pounds per foot of rope. Average value

Hence,

$$t = \frac{(T - F)}{3} + F \quad \ldots\ldots\ldots \quad (4).$$

The sum of the tensions, T and t, is not the same at different speeds, as the equation (4) indicates. As F varies as the square of the velocity, there is, with an increasing speed of the

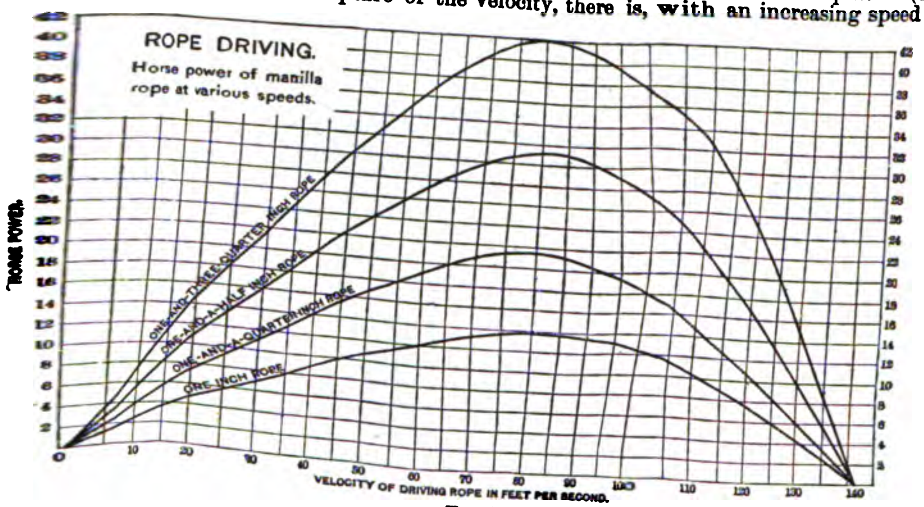


FIG. 8.

rope, a decreasing useful force, and an increasing total tension, t, on the slack side. With these assumptions of allowable strains, the horse-power will be:

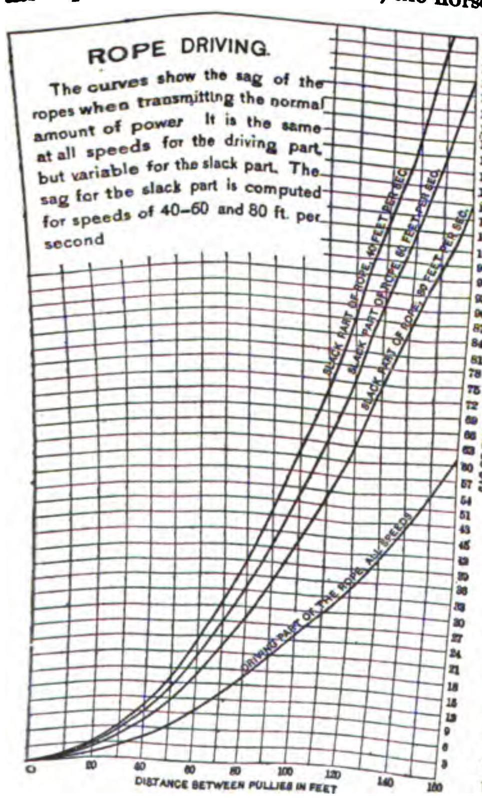


FIG. 9.

$$H. = \frac{2v(T - F)}{3 \times 550} \quad \ldots \quad (5).$$

Transmission ropes are usually from 1 to 1¾ in. in diameter. A computation of the horse-power for four sizes at various speeds and under ordinary conditions, based on a maximum strain equivalent to 200 lbs. for a rope 1 in. in diameter, is given in Fig. 8. The horse-power of other sizes is readily obtained from these. The maximum power is transmitted, under the assumed conditions, at a speed of about 80 ft. per second. The first cost of the rope will be smallest when the power transmitted by it is greatest, and under the assumed conditions will be a minimum for a given power when the velocity of the rope is about 80 ft. per second. The deflection of the rope between the pulleys on the slack side varies with each change of the load or change of the speed, as the tension equation (4) indicates. The curves in Fig. 9, giving the deflection of the rope, were computed for the assumed value of T and t by the parabolic formula:

$$S = \frac{PL^2}{8D} + PD.$$

S being the assumed strain, T, on the driving side, and t, calculated by equation (4), on the slack side. The tension, t, varies with the speed, and the curves, showing the sag of the rope in inches, are calculated for speeds of 40, 60, and 80 ft. per second, and for spans commonly used in rope driving. The following table of the horse-power of transmission rope is calculated by formula (5), which makes the total strain on the driving side of the rope, when transmitting the normal power, the same at all speeds, and takes into consideration the effect of the centrifugal force in reducing the driving power of the rope:

Machines for shop and pole rounding and heel tapering will be found described under molding machinery.

Bicycle: see Cycle.

Bits: see Quarrying Machines.

Blanchard Lathe: see Lathes, Wood-Working, and Hat Machines.

Blast-Furnaces: see Furnaces, Blast. **Stoves**: see Stoves, Hot-Blast.

Blasting: see Quarrying Machinery.

BLOCKS. *Batt's Differential Pulley-Block*, made by the Boston & Lockport Block Co., is shown in Fig. 1. The disk-pulley carrying the hand-chain has cast upon its side a scroll or spiral groove which meshes into the teeth of a wheel placed at right angles to it which carries upon its side the sprocket-wheel for the load chain. The angle of the spiral groove being low, it exerts a powerful purchase on the hoisting wheel. The friction is sufficient to sustain the load.

Alfred Box & Co.'s Double-Screw Hoist is shown in Fig. 2. The power is applied through the chain *g* on the large sprocket-wheel *E*, seen at the left of the cut, which drives a double worm, *C D*, geared right and left into two worm-wheels, *A B*, which also are geared into each other. One of these carries the sprocket-wheel for the hoisting chain *f*. Both chains are always kept in place by the guides.

The Detroit Sure-Grip Tackle-Block is shown in Fig. 3. The brake which will hold the load at any point is simply a wedge that drops by gravity between the upper sheaves. The face of the wedge is fluted to the curve of the rope. The block is made of steel. The arrows in the cut show the direction of the rope through the blocks. It will be noticed that the two center ropes that come in contact with the wedge both travel in the same direction at the same time.

Fig. 1.—Differential pulley-block.

Fig. 2.—Double-screw hoist.

Fig. 3.—"Sure-grip tackle-block.

Weston's Triplex Spur-Gear Block, made by the Yale & Towne Mfg. Co., is shown in Figs. 4, 5, 6, and 7. Figs. 4 and 5 are external views of the block suspended as for use; Fig. 6 is a transverse view, the lower half being shown in section, and Fig. 7 a section showing the hoisting mechanism. All of the mechanism is symmetrically grouped upon a single horizontal axis, and is so arranged as to occupy as little vertical space as possible. Power is applied to an endless hand-chain passing over the pocketed chain-wheel on one end of the central shaft, and is transmitted thereby to the train or spur-gearing contained in the housing on the other side of the block. The main or load chain passes over a pocketed chain-sheave in the center of the block, one of its ends being provided with a suitable hook for receiving the load, and the other being looped up and permanently secured to the frame of the block. Referring to Fig. 6, the hand-wheel at the left transmits power through the central shaft to the steel pinion on its opposite end (seen best in Fig. 7), which in turn engages with the three planet-wheels surrounding it. These latter are of hard bronze, and have cast with them a smaller series of pinions, shown in Fig. 6, which latter engage with the annular gear cast in the stationary frame of the block, as shown in Fig. 7. The three double planet wheels are carried in a frame or cage which supports both ends of each of the pins forming the axis of the wheels. As the central shaft is turned, the whole cage and its three pinions thus rotate slowly within the housing of the block. The inner side of the pinion cage consists of a disk keyed to one end of the steel sleeve forming part of and carrying the hoisting-chain sheave, so that the rotary motion of the pinion cage is thus transmitted to the chain-sheave. The two hubs of the latter are prolonged to form bearings on each side in the frame of the block, and are bored through the center to permit the shaft of the hand-chain wheel to pass

Comparative Efficiency of Blocks, both in Hoisting and Lowering.

Work of hoisting (load of 2,000 lbs.). Actual efficiency. Per cent.	Relative efficiency.	Velocity ratio.	Number of block. All blocks of 1-ton capacity.	Work of lowering (load of 2,000 lbs. lowered 7 ft. in each case), inclusive of time. Time in minutes.	Relative efficiency.
79·50	1·00	32·50	1 (Weston's triplex.)	0·75	1·000
32	0·40	62·44	2	1·20	0·186
31	0·39	30	3 (Weston's differential.)	1·50	0·050
28·80	0·36	28	4 (Weston's imported.)	2·50	0·035
26·04	0·33	48	5	2·80	0·380
24·34	0·31	53	6	1·80	0·086
23	0·29	44·30	7	2·75	0·029
18·97	0·24	61	8	3·75	0·018

BLOWERS. (See Air Compressors, Boilers, Steam, and Engines, Blowing.) *Fan-Blowers.*—Fig. 1 shows a type of fan which has come into extensive use for ventilating, drying, and similar purposes where a large volume of air is to be moved at a slight pressure. The shapes of the blades vary in the fans made by different makers. The accompanying table gives the speed, horse-power used, and cubic feet of air exhausted per minute when there is no obstruction, according to the catalogue of the L. J. Wing Co., makers of the fan shown in the cut:

Size.	Revolutions per minute.	Horse-power used.	Exhaust cubic feet of air per minute.
12 in.	1,000 to 2,000	1/16 to 1/2	1,500 to 3,000
18 in.	700 to 1,500	1/4 to 1/2	3,000 to 6,000
24 in.	600 to 1,200	1/4 to 3/4	4,500 to 9,000
30 in.	500 to 1,000	1/2 to 1	7,000 to 15,000
36 in.	400 to 900	3/4 to 2 1/4	12,000 to 26,000
42 in.	400 to 800	1 to 2 1/2	18,000 to 36,000
48 in.	400 to 700	1 1/16 to 5	26,000 to 45,500
54 in.	400 to 600	2 to 5 1/2	32,000 to 48,000
60 in.	400 to 550	2 1/4 to 6	42,800 to 60,000
72 in.	300 to 450	2 1/2 to 6 1/2	45,000 to 67,500
84 in.	250 to 400	3 to 10	56,000 to 89,600
96 in.	200 to 300	3 1/2 to 10	63,000 to 96,500

The Smith Double-Discharge Fan-Blower.—Fig. 2 is a diagram showing the principle of the double-discharge fan-blower in contrast with that of the ordinary fan shown in Fig. 3. To secure the double discharge the case is extended on the rear and a second outlet provided, which is led around under the first to the front, to the two outlets uniting in one at the discharge. The construction is common to both pressure and exhaust fans. The principle is thus described by the makers: It is experimentally demonstrated that the vane of a fan, operating normally, becomes loaded with air in one third of a revolution. In Fig. 3, representing the ordinary single-discharge blower, the compartment *a* is partly loaded, *b* nearly so, and *c* fully loaded. This air it seeks to deliver; but, as there is no outlet, the wheel must drag the accumulated pressure with its accompanying friction around half the circumference of the shell before it can be relieved at *A*. The double-discharge blower is claimed to unload the air at *A* as soon as the full pressure is accumulated, and immediately picks up and discharges another full load at *B* in the same revolution.

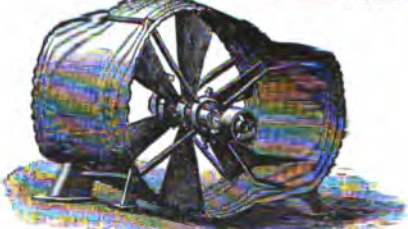


FIG. 1.—Fan-blower.

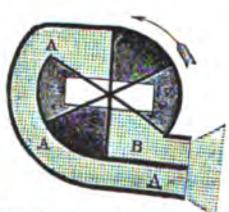


FIG. 2.—Double-discharge blower.

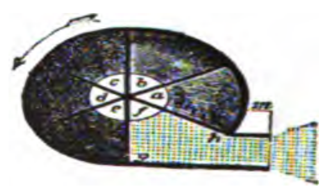


FIG. 3.—Single-discharge blower.

Tilghman's Steam-Jet Exhauster.—The ordinary steam-jet exhauster is such a simple and venient apparatus that it would be used much more largely than it is—were it not for its efulness of steam. It has, however, been noticed that small jets are more efficient than ones, showing that the surface of contact of the jet with the air is of importance rather the cross-section of the jet. With the object of increasing this surface of contact, in a steam-jet exhauster the steam issues radially between two disks fixed at the end of the -pipe. Openings through these disks lead into branches connected with the suction- hrough which the air is drawn. The thin, radial stream of steam in flowing over these gs takes up its full quota of air, and the manufacturers claim that a very considerable of steam is effected. The thickness of the jet is regulated by the hand-wheel, the of which is attached to the lower disk. The best distance between these disks is be 1/100 in. to 1/50 in. The exhauster works with a complete absence of noise. Though

water is impure, but no other boiler can be used on a locomotive. In the attempt to combine as many as possible of these good qualities in a single boiler, and in the fallacious hope of improving on the economy of established types, hundreds of new boilers have been invented during the last ten years, and many put on the market, in which the first principles of good construction are violated. These new boilers, however, generally disappear from the market in a few years, and they do not prevent the course of progress toward the use of a few standard types only, each adapted to certain locations. In these types there is nothing new in general principles of construction, and such improvements as have been made are confined to details.

The common vertical tubular boiler still holds a prominent position, on account of its qualities of economy of floor-space and the first cost. It still also holds its bad pre-eminence as first in the list of dangerous boilers—more explosions of this type being recorded than of any other. Improvements in details in this boiler have been introduced by some makers which tend to render it less dangerous, by providing for complete circulation of the water and giving greater facilities for cleaning.

The common horizontal tubular boiler has not been improved in the last ten years, except in proportions used by some makers. It remains as the most extensively used boiler in the United States, especially for moderate-sized plants, while in Europe it has never obtained much of a footing, being there considered a highly dangerous boiler. In this country its great success has been chiefly due to its low first cost; but it is now becoming less of a favorite, as the water-tube boiler is coming more extensively into use.

The water-tube type of boiler for land purposes has achieved an extraordinary growth during the past ten years, and it gives promise of soon being the most common form of boiler. In Europe its use is still more common than in this country, and the principal boiler exhibits at the Paris Exhibition of 1889 were of that type. Numerous modifications of the type have been brought out by different makers, but the most approved form which is now adopted by several makers in this country consists of a bank of 4-in. water-tubes, inclined at an angle of about 15°, with the horizontal surmounted by one or more horizontal water and steam drums about 36 in. in diameter. At the Philadelphia Exhibition in 1876 several water-tube boilers were shown, but the Babcock & Wilcox was the only one of the particular variety above described. This variety, however, has shown the strongest power of survival, and it is now adopted, as above said, by many makers.

In marine boilers the tendency has been to abandon a great variety of types hitherto used, and to bring into almost universal use the "Scotch" form of boiler, a plain cylindrical shell of large diameter, with two or more furnaces, leading by a vertical passage into numerous horizontal tubes. For large boilers of this type the use of the corrugated furnace-flues has become almost universal. The water-tube boiler of the general pattern used on land has not yet come into any general use at sea, although the Belleville boiler, made in France, has met success in this direction. There has, however, come into use a different type of marine water-tube boiler, in which small tubes about 1 or 1¼ in. in diameter are used with small water-drums or reservoirs, or none at all. The latter form, without drums, is known as the coil boiler. Its sole reason for existence is that it affords the largest amount of heating surface for a given bulk and weight, and is therefore used for torpedo-boats and high-speed steam-launches. The other form with water-drums approaches more nearly to the land type of water-tube boiler, and in it efforts are made to combine the desirable features of the coil boiler with the steady water-level, accessibility for repairs, and general durability of the ordinary form of water-tube boiler. Several such boilers are now in use on steam-yachts, and it is proposed to use them on large ocean-going vessels, but it is too early yet to say whether any of the forms will prove permanently successful. The increase in steam pressures carried in ocean vessels in recent years, up to 160 lbs. or more, makes it necessary that the Scotch form of boiler shall be built of steel plates over 1 in. in thickness. This, with its great diameter, makes it an exceedingly heavy, bulky, and costly boiler for the power it develops; and there is great need for the introduction of a new type of boiler which shall admit of the still higher pressures now desired, and be lighter and more economical of room than the present form. It is probable that some form of water-tube boiler will soon be introduced to meet these requirements.

The most important general change in the construction of boilers in recent years has been the almost complete substitution of soft steel plates for the wrought-iron plates formerly used. The use of steel for steam-boilers dates back to 1856 in England and 1862 in the United States, but it required many years to bring it into general employment. The objections to it when first introduced were that it was made too high in carbon and phosphorus, the necessity for making the steel very soft then not being understood, consequently cracked sheets were very common, and also that it was high-priced. With the introduction of the open-hearth process in France about 1867 and in the United States in 1869, a softer grade of steel was made, which, after it was learned that low phosphorus as well as low carbon was necessary for good boiler-plate, became entirely successful, and better in quality than the best boiler-iron. The improvements in steel furnaces and plant have recently greatly cheapened the cost of steel boiler-plate, so that it can be made at a much lower cost than even ordinary grades of boiler-iron, and it has therefore practically driven the latter out of the market. The quality of steel desired for boiler and fire-box plates may be seen from the following specifications given by different authorities:

United States Navy.—Shell: Tensile, 58,000 to 67,000 lbs.; elongation, 22 per cent in 8 in. transverse section, 25 per cent in 8 in. longitudinal section. Flange: Tensile, 50,000 to 58,000 lbs.; elongation, 25 per cent in 8 in. Chemical requirements: Phosphorus, not over

$1\frac{1}{4}$ in. below the upper head to within about 10 in. of the bottom of the water-leg of the boiler, and completely surrounding the tubes. Midway between this apron and the boiler-shell is suspended from, and joined to, the upper head a perforated plate, which extends downward about 20 in., encircling the apron. The effect produced by the apron and perforated plate is that when the boiler is subjected to heat from its furnace, the water surrounding the tubes ascends and is replaced by the cold water from the space between the apron and the boiler-shell. As the heat increases, the circulation around the apron becomes more rapid, the water within the apron and around the tubes being forced to and over the top of the apron where the separation of water and steam takes place; the latter passing through the perforated plate to the space between the boiler-shell and that plate, and the former descending to the water contained between the apron and boiler-shell. The steam is drawn from the boiler through an opening in the shell near the upper head. The separation of the water and steam is thorough, as the water after passing over the apron has a downward tendency, which, with its greater weight, causes it to descend; while the steam readily passes through the perforated plate, and is found in the outer space free from entrained water.

FIG. 4.—Payne's boiler.

Marine Boilers with Corrugated Flues.—Nearly all ocean-going steamers are now fitted with boilers of the Scotch type. Two of these boilers are shown in Figs. 5 and 6. These boilers were made by Messrs. J. & G. Rennie, of London. The use of corrugated furnace-flues, or of some substitute for them, as flues with stiffening ribs, has become almost universal since the use of high pressures of steam 100 lbs. and upward. The marine boilers used in the United States gun-boats Yorktown, Concord, and Bennington, have each three corrugated furnace-flues leading into one common back connection. From here the products pass along through the nest of tubes to the chimney. The British Board of Trade in 1891 adopted a new formula for the working pressure allowable on corrugated furnaces, as follows: $WP = \frac{14000 \times T}{D}$, in which WP is the working pressure in lbs. per sq. in., T thickness in

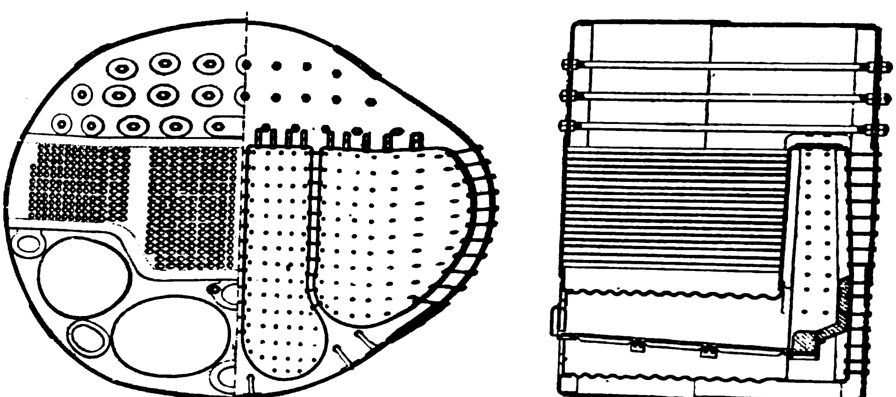


FIG. 5.—The Rennie boiler.

in., and D mean diameter in in. Lloyd's Registry have also adopted a new formula, as follows: $WP = \frac{1234 \times T^2}{D}$, in which T is the thickness in sixteenths of an in., and D the greatest diameter in in.

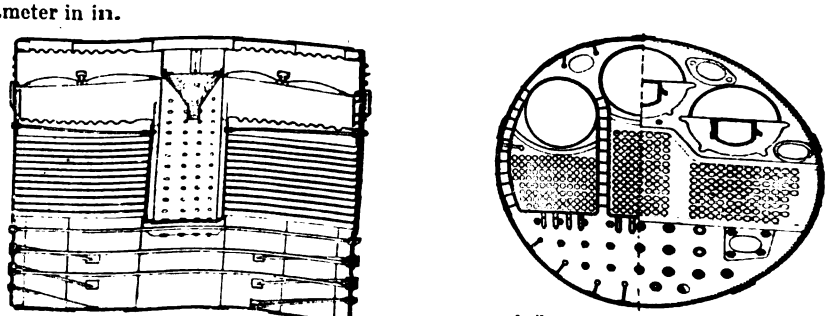


FIG. 6.—The Rennie boiler.

(inclosed inside of the steam and water drum) forms a receptacle in which the feed-water is gradually heated to approximately the temperature of the water in the boiler, and as it issues from the front top of the same in a thin current, it mixes with the main current flowing backward in the shell, and the expansion strains from changes in temperature are practically eliminated. 6. Access is given to the outside of the tubes through hollow stay-bolts in the

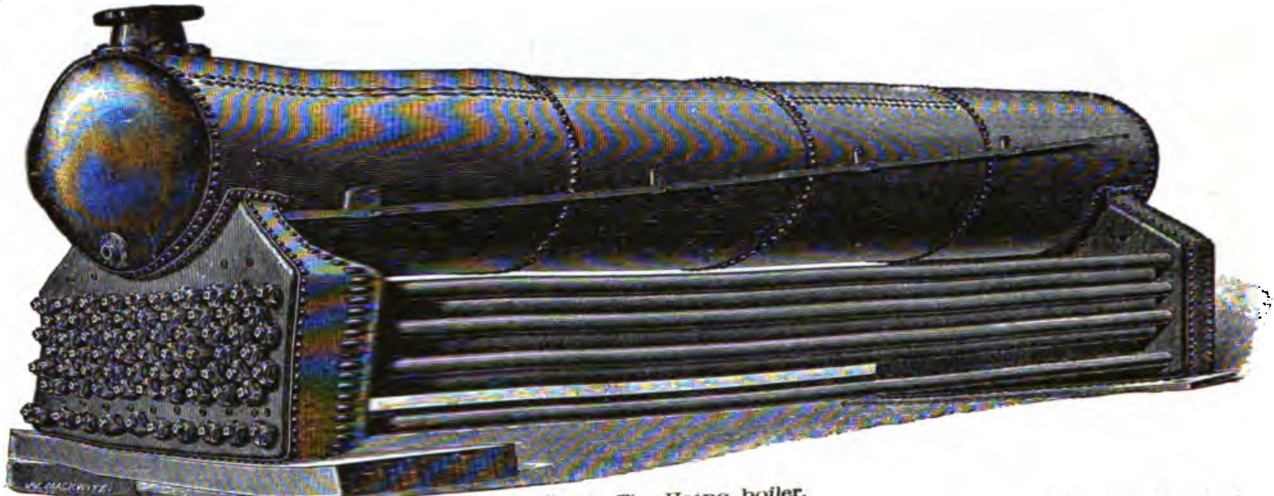


FIG. 9.—The Heine boiler.

water-legs at all times, so that the tube-heating surfaces can be inspected, cleaned, and watched while the boiler is under steam. 7. All the hand-hole plates opposite ends of tubes have internal joints, thus doing away with the danger resulting in other types from broken bolts in the headers. 8. The mode of setting practically prevents the flame or hot gases from striking the riveted work of the shell, until their temperature has been reduced to about 900° F., or less.

Gill's Water-Tube Boiler.—The Gill boiler, Fig. 10, is a representative of a number of new water-tube boilers that have come into use during the past ten years, of the general type which has become standard, and apparently permanent, having a horizontal drum in which

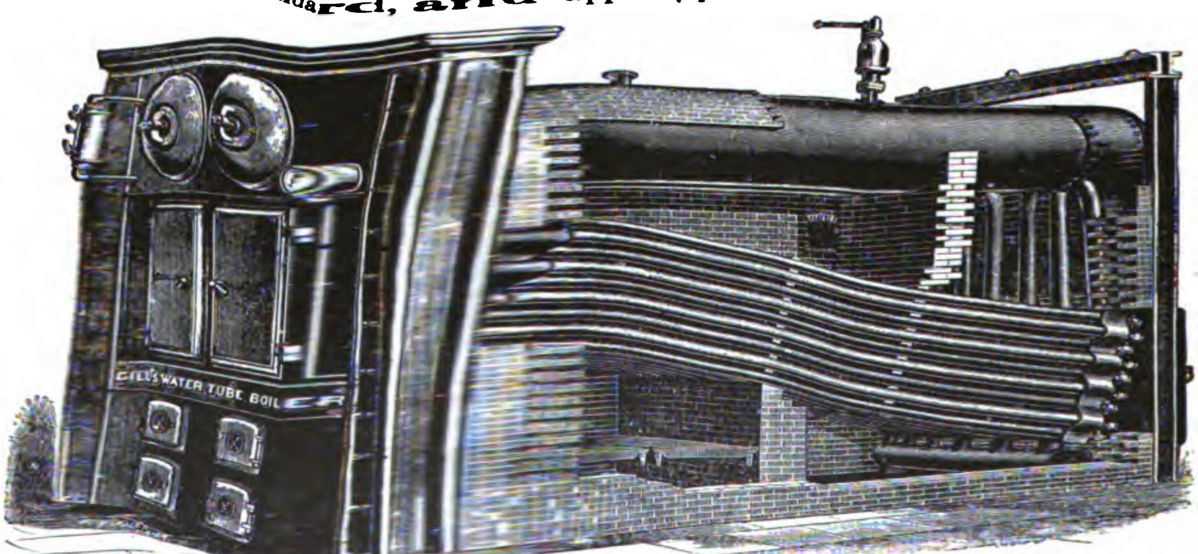


FIG. 10.—The Gill boiler.

water-level is carried at or near the middle, and a bank of inclined tubes connected with headers, which latter are connected by circulating pipes to the drum. The Gill boiler differs from other boilers of this standard type merely in the details of construction of the headers.

Mosher, and Cowles. Detail drawings of some of them, and records of tests made by engineers of the U. S. Navy, are given in the Report of the Chief of the Bureau of Steam-Engineering for 1890. The Cowles boiler is selected here as a representative of the general type. It is described as follows by its patentee, Mr. William Cowles, of Brooklyn, N. Y., and consists of a rectangular grate and ash-pan, over which is set horizontally a cylindrical shell for steam and

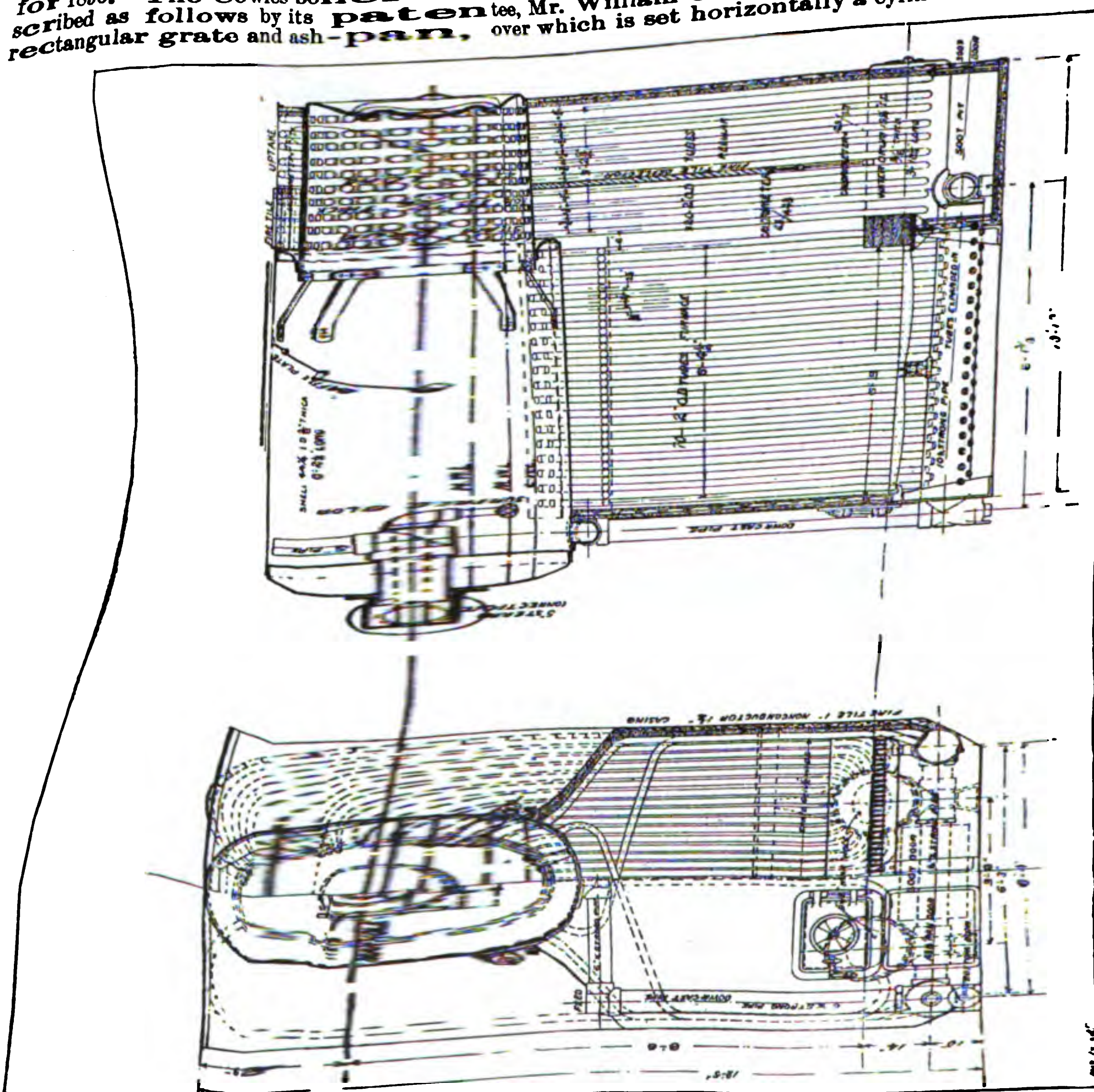


Fig. 13.—The Cowles boiler.

water; from the back part of this shell a steam-drum projects back horizontally; from its front end large "downcast" pipes extend down to large side pipes at each side and below the furnace; these side pipes connect at their back ends with the water-drums lying horizontally back of the furnace and below or at its level; numerous bent water-tubes, with ends expanded in, extend vertically and connect between the water and steam drums and between the side pipes and shell. The whole is inclosed in a suitably lined casing for marine use and in masonry for stationary work.

Mosher's Water-Tube Boiler.—Figs. 14, 15, 16, and 17 illustrate the boiler designed by Mr. C. D. Mosher for the fast steam-launch Norwood, owned by N. L. Munro, of New York City. It has several novel features. For the power the boiler has to furnish, it occupies but very small space, and its center of gravity is very low. It has 26 sq. ft. of grate surface, and about 1,000 sq. ft. of heating surface. The tubes are made of steel, 1 in. diameter, solid drawn. weight of the boiler and water is 2¼ tons; its length is 7 ft. 3 in.; breadth, 6 ft.; total

the inner casing k. The lower ends of the tubes f^4 are marked 12, 13, in Fig. 16. The wall composed of the tubes f^4 extends the entire length of the furnace. The spaces between the inner and outer walls of tubes contain the tubes f^5, which are of the same general form as the tubes f and f^4, but are separated, so that the products of combustion pass freely around each tube. With this arrangement the steam-drums are protected from the direct action of the fire by the interposed tubes, and can be affected only by the radiation of heat from the hot gases that pass through the spaces 10 at the rear portion of the fire-box; hence, the liability of burning or injuring the drums by overheating is reduced to a minimum. As an additional protection to the steam-drums, the partitions k k, previously referred to, are interposed between the lower portions of the steam-drums and the furnace; these partitions lie close to the wall formed by the tubes f^4, as shown in Fig. 16.

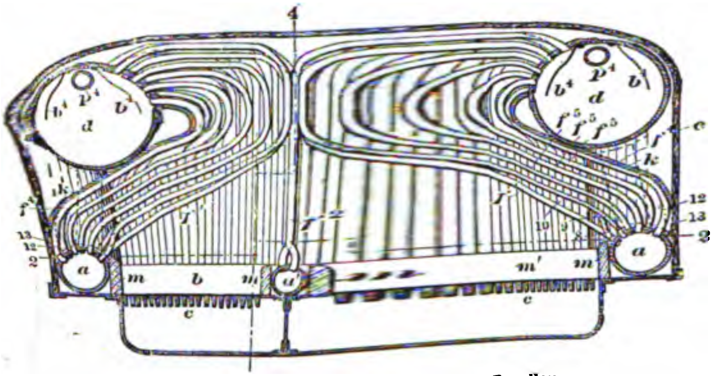


FIG. 16.—The Mosher boiler.

The smoke-stack g is placed over the forward end of the furnace, as shown in Fig. 17, causing the products of combustion, after passing through the spaces 10, to travel in the opposite direction toward the forward end of the furnace, as indicated by the dotted arrows in Fig. 17, the tubes being thus exposed to the action of the heat. This arrangement is another important feature of the invention. A baffle-plate or deflector, h, is placed across the upper portion of the furnace, just in the rear of the smoke-stack, as shown in Fig. 17, which causes the products of combustion to take a downward course, as indicated by the dotted arrows, before reaching the smoke-stack, and prevents the too direct escape of the products of combustion, and causing the same to act more fully upon the water in the tubes. The products of combustion pass to the stack through the openings formed between the tubes f and f^2, the latter being raised above the tubes f forward of the deflector h, as shown in Fig. 17, leaving spaces between the horizontal portions of the tubes f and f^2 of sufficient width to permit the passage of the smoke and gases to the stack. The ends of the steam-drums are connected with the ends of the water-drums by the pipes i for the return of water from the steam-drums to the water-drums. These return pipes are located outside of the casing e, as is shown in Fig. 15, and are not subjected to the heat within the casing; hence the descent of water through the return pipes to the water-drums is facilitated. Baffle-plates b^4, b^4, shown in Fig. 16, are attached to the upper portions of the steam-drums at opposite sides of the perforated dry-pipes p^4, which extend through the drums, and are connected outside of the drums with pipes which conduct the steam to the engine. The water-drums are protected from contact with the fuel by the fire-brick linings m, and the transverse connecting pipes a'' are protected by similar linings, m'. The water-drums act also as mud-drums, and have suitable blow-off cocks and hand-holes to allow the removal of the deposits. The tubes $f, f', f^2, f^3, f^4, f^5$, are expanded in the drums and pipes by special tools devised for this purpose. The adoption of two steam-drums, d, not only makes the boiler symmetrical, but it gives a greater height of furnace in proportion to the total height of boiler than could be obtained with one drum; and the water capacity is increased so that a sudden lowering of water-level in the boiler when the supply of feed-water is interrupted is prevented.

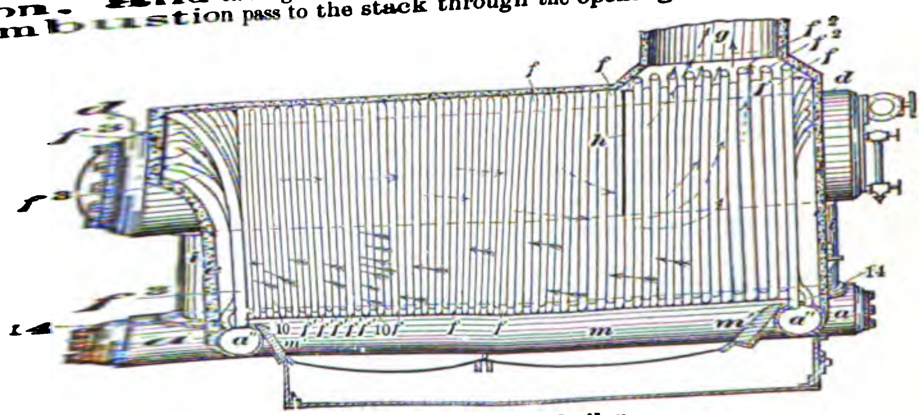


FIG. 17.—The Mosher boiler.

Non-conducting Coverings for Boilers, etc.—W. Hepworth Collins, in *Engineering*, Sept. 1891, describes some experiments he made on different non-conducting coverings for steam-boilers. A mass of each material to be experimented upon, 1 in. thick, was carefully prepared and placed on a perfectly flat iron plate or tray, which was then carefully maintained at a constant temperature of 310° F. The heat transmitted through each non-conducting mass was calculated in pounds of water heated 10° F. per hour. The following table gives the results:

"VII. *Before beginning a test* the boiler and chimney should be thoroughly heated to their usual working temperature. If the boiler is new, it should be in continuous use at least a week before testing, so as to dry the mortar thoroughly and heat the walls.

"VIII. Before beginning a test the boiler and connections should be free from leaks, and all water connections, including blow and extra feed-pipes, should be disconnected or stopped with blank flanges, except the particular pipe through which water is to be fed to the boiler during the trial. In locations where the reliability of the power is so important that an extra feed-pipe must be kept in position, and in general when for any other reason water-pipes other than the feed-pipes can not be disconnected, such pipes may be drilled so as to leave openings in their lower sides, which should be kept open throughout the test as a means of detecting leaks, or accidental or unauthorized opening of valves. During the test the blow-off pipe should remain exposed. If an injector is used it must receive steam directly from the boiler being tested, and not from a steam-pipe, or from any other boiler. See that the steam-pipe is so arranged that water of condensation can not run back into the boiler. If the steam-pipe has such an inclination that the water of condensation from any portion of the steam-pipe system may run back into the boiler, it must be trapped so as to prevent this water getting into the boiler without being measured.

"STARTING AND STOPPING A TEST.—IX. A test should last at least ten hours of continuous running, and twenty-four hours whenever practicable. The conditions of the boiler and furnace in all respects should be, as nearly as possible, the same at the end as at the beginning of the test. The steam pressure should be the same, the water-level the same, the fire upon the grates should be the same in quantity and condition, and the walls, flues, etc., should be of the same temperature. To secure as near an approximation to exact uniformity as possible in conditions of the fire and in temperatures of the walls and flues, the following method of starting and stopping a test should be adopted:

"X. *Standard Method.*—Steam being raised to the working pressure, remove rapidly all the fire from the grate, close the damper, clean the ash-pit, and as quickly as possible start a new fire with weighed wood and coal, noting the time of starting the test and the height of the water-level while the water is in a quiescent state, just before lighting the fire. At the end of the test, remove the whole fire, clean the grates and ash-pit, and note the water-level when the water is in a quiescent state; record the time of hauling the fire as the end of the test. The water-level should be as nearly as possible the same as at the beginning of the test. If it is not the same, a correction should be made by computation, and not by operating pump after test is completed. It will generally be necessary to regulate the discharge of steam from the boiler tested by means of the stop-valve for a time while fires are being hauled at the beginning and at the end of the test, in order to keep the steam pressure in the boiler at those times up to the average during the test.

"XI. *Alternate Method.*—Instead of the standard method above described, the following may be employed where local conditions render it necessary: At the regular time for slicing and cleaning fires, have them burned rather low, as is usual before cleaning, and then thoroughly cleaned; note the amount of coal left on the grate as nearly as it can be estimated; note the pressure of steam and the height of the water-level—which should be at the medium height to be carried throughout the test—at the same time; and note this time as the time of starting the test. Fresh coal, which has been weighed, should now be fired. The ash-pits should be thoroughly cleaned at once after starting. Before the end of the test the fires should be burned low, just as before the start, and the fires cleaned in such a manner as to leave the same amount of fire, and in the same condition, on the grates as at the start. The water-level and steam pressure should be brought to the same point as at the start, and the time of the ending of the test should be noted just before fresh coal is fired.

"DURING THE TEST.—XII. *Keep the Conditions uniform.*—The boiler should be run continuously, without stopping for meal-times or for rise or fall of pressure of steam due to change of demand for steam. The draft being adjusted to the rate of evaporation or combustion desired before the test is begun, it should be retained constant during the test by means of the damper. If the boiler is not connected to the same steam-pipe with other boilers, an extra outlet for steam with valve in same should be provided, so that in case the pressure should rise to that at which the safety-valve is set it may be reduced to the desired point by opening the extra outlet without checking the fires. If the boiler is connected to a main steam-pipe with other boilers, the safety-valve on the boiler being tested should be set a few pounds higher than those of the other boilers, so that in case of a rise in pressure the other boilers may blow off, and the pressure be reduced by closing their dampers, allowing the damper of the boiler being tested to remain open, and firing as usual. All the conditions should be kept as nearly uniform as possible, such as force of draft, pressure of steam, and height of water. The time of cleaning the fires will depend upon the character of the fuel, the rapidity of combustion, and the kind of grates. When very good coal is used, and the combustion not too rapid, a ten-hour test may be run without any cleaning of the grates, other than just before the beginning and just before the end of the test. But in case the grates have to be cleaned during the test, the intervals between one cleaning and another should be uniform.

"XIII. *Keeping the Records.*—The coal should be weighed and delivered to the firemen in equal portions, each sufficient for about one hour's run, and a fresh portion should not be delivered until the previous one has all been fired. The time required to consume each portion should be noted, the time being recorded at the instant of firing the first of each new portion. It is desirable that at the same time the amount of water fed into the boiler should

Results of Tests of Horizontal Tubular Boilers with Anthracite Coal.

	Ratio of heating to grate surface.	Per cent of ash.	Coal per hour per sq. ft grate.	Temperature of escaping gas.	Water per lb. combustible from and at 212° F.
			Lbs.	Deg. F.	
Average of 16 boilers	44·7 to 1	12·2	11	357·9	10·76
Highest economy	35·6 to 1	13·4	6·7	321	11·37
Lowest economy	26·5 to 1	10·1	12·9	455	9·75

In general, the highest results are produced where the temperature of the escaping gases is the least. An examination of this question is made by Mr. Barrus, by selecting those tests made by him, six in number, in which the temperature exceeds the average, that is 375°, and comparing with five tests in which the temperature is less than 375°. The boilers are all of the common horizontal tubular type, and all use anthracite coal of either egg or broken size. The average flue temperature in the two series are 444° and 343°, respectively, and the difference is 101°. The average evaporations are 10·40 lbs. and 11·02 lbs., respectively, and the lowest result corresponds to the case of the highest flue temperature. In these tests it appears, therefore, that a reduction of 101° in the temperature of the waste gases secured an increase in the evaporation of 6 per cent. This result corresponds quite closely to the effect of lowering the temperature of the gases by means of a flue-heater in another test, where a reduction of 107° was attended by an increase of 7 per cent in the evaporation per lb. of coal. A similar comparison was made on ten horizontal tubular boilers using Cumberland coal. The average flue temperature of the ten boilers was 415°. Four of them had temperatures exceeding 415°, their average temperature being 450°, and average evaporation 11·34 lbs. The other six had temperatures below 415°, averaging 383°, and their average evaporation was 11·75 lbs. With 67° less temperature of the escaping gases, the evaporation is higher by about 4 per cent. The difference here is less marked than in the anthracite tests, both in range of temperature and in economy, but it is in the same direction; that is, the highest evaporation is produced where the waste at the flue is the least. The wasteful effect of a high flue temperature is exhibited by other boilers than those of the horizontal tubular class. This source of waste was shown to be the main cause of the low economy produced in those vertical boilers which are deficient in heating surface. As to the proper ratio of heating to grate surface, Mr. Barrus concludes that a ratio of 36 to 1 provides a sufficient quantity of heating surface to secure the full efficiency of anthracite coal where the rate of combustion is not more than 12 lbs. per sq. ft. of grate per hour, and a ratio of 45 to 50 to 1 for bituminous coal. As to tube area he concludes that the highest efficiency with anthracite coal is obtained when the tube opening is from one ninth to one tenth of the grate surface; but a large tube opening is required with bituminous coal, the best results being obtained where the tube opening was from one fourth to one seventh of the grate area. The general conclusion drawn from all these comparisons is that the economy with which different types of boilers operate depends much upon their proportions and the conditions under which they work, than upon their type; and, moreover, that when these proportions are suitably carried out, and when the conditions are favorable, the various types of boilers give substantially the same result.

Prevention of Corrosion of Marine Boilers.—Mr. H. J. Bakewell, in *Proc. Inst. Mech. Eng.*, August, 1884, p. 352, writes, concerning the British Admiralty practice on the treatment of marine boilers, as follows:

"The investigations of the Committee on Boilers served to show that the internal corrosion of boilers is greatly due to the combined action of air and sea-water when under steam, and when not under steam to the combined action of air and moisture, upon the unprotected surfaces of the metal. There are other deleterious influences at work, such as the corrosive action of fatty acids, the galvanic action of copper and brass, and the inequalities of temperature; these latter, however, are considered to be of minor importance.

"Of the several methods recommended for protecting the internal surfaces of the boilers, the three found most effectual are: firstly, the formation of a thin layer of hard scale deposited by working the boiler with sea-water; secondly, the coating of the surfaces with a thin wash of Portland cement, particularly wherever there are any signs of decay; thirdly, the use of zinc slabs suspended in the water and steam spaces. As to general treatment for the preservation of boilers in store or when laid up in the reserve, either of the two following methods is adopted, as may be found most suitable in particular cases: Firstly, the boilers are dried as much as possible by airing stoves, after which 2 to 3 cwt. of quicklime, according to the size of the boiler, is placed on suitable trays at the bottom of the boiler and on the tubes. The boiler is then closed and made as air-tight as possible. Periodical inspection is made every six months, when if the lime be found slacked it is renewed. Secondly, the other method is to run the boilers up with sea or fresh water, having soda added to it; if ordinary crystal soda be used, the proportion is 1 lb. of soda to every 100 or 120 lbs. of water. The sufficiency of the saturation can be tested by introducing a piece of clean new iron, and leaving it in the boiler for ten or twelve hours; if it shows signs of rusting, more soda should be added. It is essential that the boilers be entirely filled, to the complete exclusion of air. The working density of the water used in boilers is from 2½ to 4 times the saltness of sea-water; a high density has been found beneficial in point of cleanliness. It is considered advantageous to retain the water in boilers without change as long as possible, whether the boilers are alight or not, and to remove it only when dirty, or when necessary for cleaning and examination, the boilers being filled up quite full when not required for steaming.

steam varies less than 1 per cent from the condition of saturation either in the direction of wetness or superheating.

II. If a jet of steam flow from a boiler into the atmosphere under circumstances such that very little loss of heat occurs through radiation, etc., and the jet be transparent close to the orifice, or be even a grayish-white color, the steam may be assumed to be so nearly dry that no portable condensing calorimeter will be capable of measuring the amount of water in steam. If the jet be strongly white, the amount of water may be roughly judged up to about 2 per cent, but beyond this a calorimeter only can determine the exact amount of moisture.

III. A common brass pet cock may be used as an orifice, but it should, if possible, be set into the steam-drum of the boiler, and never be placed farther away from the latter than 4 ft., and then only when the intermediate reservoir or pipe is well covered.

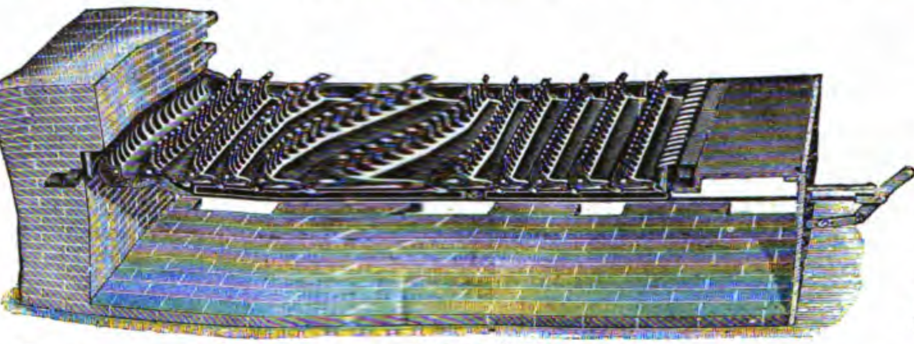


FIG. 18.—The McClave grate.

The McClave Grate and Furnace-Blower.—Fig. 18 shows a new form of shaking grate recently devised for burning anthracite buckwheat and culm, together with a steam-blower used under the grate for the purpose of creating a forced blast without a great excess of steam. This grate operates on the pocket principle—i. e., when the grate-bars are thrown wide open, a series of pockets are formed by them to receive the clinkers and ashes, but which can not pass through into the ash-pit until the bars are thrown back into their normal position, thus mowing a certain quantity of clinkers and ashes from the under side of the fire instantly and uniformly at each cut. The Argand steam-blower, shown in Fig. 19, is used in connection with the McClave grate to furnish a forced draft. It furnishes a large volume of air with a small amount of steam; and the air and steam are thoroughly mixed in the shell or case of the blower before the blast is delivered into the ash-pit. It is now generally conceded that a blast furnished by under-grate blowers is better adapted to burn small fuels, such as buckwheat, birdseye, culm, slack, etc., than either a strong natural draft, or yet a draft produced by a jet or jets in the stack. The idea of a combined air and steam blast has gradually grown into favor on account of the effect of the steam on the fire. It is a well-established fact, however, that while a small quantity of steam is a valuable constituent in blast, yet an excess of steam defeats the very purpose for which it was intended, by over-taxing the decomposing power of the fire with too large a quantity of steam, which passes through the fire simply as steam, thereby losing the value of the oxygen it contains, nearly the entire product of the fire being in such case carbonic oxide, with no available oxygen present to combine with it. The mechanical effect of the steam is that it keeps the clinkers soft and porous, so that the blast will readily pass up through the entire bed of fuel uniformly, instead of being forced to pass between solid clink-ers wherever it can find an opening, thus producing what is gener-lly termed forge flames under the boiler, as is usually the case ith a fan-blast; for with an all-air blast the clinkers generally rm into compact slabs, through which the air can not pass. herefore, while heat is absorbed in the decomposition of steam, t the heat thus absorbed is more than compensated for by the neficial nature of the general result thus obtained. See also gines, Steam Fire, Locomotive, Ice-Making Machines, and Drill-Machines, Metal.

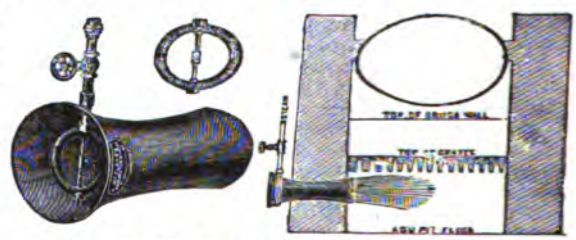


FIG. 19.—McClave Argand blower.

BOILER-TUBE CLEANER.—*Baldwin's Boiler-Tube Clean-*s shown in Fig. 1. This cleaner differs from the ordinary tube-ner in that the deposits, instead of being blown out of the tubes the back connection, are drawn by a partial vacuum from the end to the front, and discharged into the chimney, or other nient place, without admitting steam into the tubes. This is plished by an apparatus working upon the injector principle. is admitted through the small apertures shown. A strong suction is produced in the n of the arrows. The larger end is held into the boiler-tube, a packing securing tight

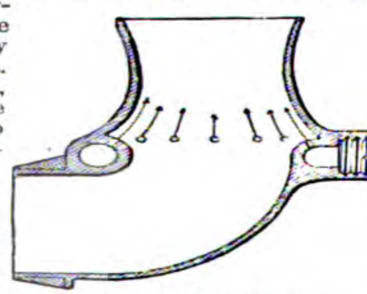


FIG. 1.—Tube cleaner.

center of the sheet are the same as at either end—practically "kettle-stitches"; these stitches are shorter (about 1 in.) and more numerous. Each sheet receives the same number of stitches, and forms practically what is termed "all along" or "one sheet on" sewing; it is stronger even than that style of sewing, because each stitch is made independent of the bands. Every three sheets form a "lock-stitch," a distinctive feature of strength in itself. Every stitch is independent. The loss of one stitch in no way affects the others. In rounding and backing the book, no strain is brought to bear on any one stitch or thread, as is the case with "kettle"-stitches by hand-work, as every stitch, it must be remembered, is practically a "kettle"-stitch; but each sheet is brought closer together, the center tightening same as at each end, and all bearing the strain alike. The process is likened to the lacing of a shoe. This gives the book a firmness and strength in the center not found in ordinary sewing. The thread enters the book with all its original strength; it is not "frayed" away by continual use, and has in comparison no knots. The stitches alternate in every sheet, so that no unusual amount of "swell" results. As will be understood, the sheets are placed on the rotary arms. These are four in number, which carry the signature from the operator to the needles. One is always presented to the operator, and rests while the preceding arm holds its sheet for operation of needles. Working from left to right, the sheet is always in sight of the operator, and always under control. The machine runs easily at a speed of 45 sheets per minute. The latest improvement made upon this machine is the substitution of automatically operated knives for making the incisions in the fold, for the punches used in connection with the first machines. These knives lie normally within the radial arms, which are made hollow. As any arm is brought into line with the row of needles, and has risen to a point just short of contact therewith, the end of a spring-bar, to which the knives are connected inside the radial arm, comes in contact with a moving device at the side of the machine, which presses such spring-bar inward, and thus causes the connected knives to protrude from the upper edge of the arm through properly spaced apertures. The knives thus make the necessary incisions in the sheets, through which the needles work when the knives are automatically withdrawn.

Stabbing-Machines.——In a new form of power stabbing-machine the main feature is that the awls revolve. While going into and coming out of the work, they turn, thus operating much easier, especially in thick books and making a smoother and smaller hole than when the stabbing is done in the usual way. A pinion on the driving-shaft meshes with a gear upon the eccentric shaft, and the eccentric, through a vertical yoke and cross-bar connected to vertical slide rods passing through the table, and terminating in the awl cross-head, causes the latter to move up and down at proper intervals for piercing the work. The cross-head travels upon stationary guide-bars which have their own fixed head, containing threaded boxes which receive the correspondingly threaded upper ends of the awls, in this way imparting rotary motion in reversed directions to the awls as their cross-head is moved up and down by the eccentric. In forming backs for blank-books, and for small job-work, a simple machine is employed which has two pairs of rolls, of different sizes, journaled in a plain upright frame which is fixed to a table. One of each pair of rolls has self-adjusting spring bearings, and each pair is geared together. A key-crank turns either pair of rolls at the will of the operator, according to the size of back he is making. The rolls are heated by gas, by gas-pipes placed back of the rolls, and both pairs can be heated at once or separately. Each roll has an apron attached to it. The book back is formed by wetting it on one side with a sponge, and feeding it in dry side next to the roll. The roll is stopped for a moment just before the back passes out, so as to give it a chance to take shape and harden; then it is released. Bands are formed in the same way by setting them in a band board and feeding them to the roll. Among the advantages are the facilities for forming different sizes and thicknesses of backs in the same machine—and a dozen or more bands at the same time as one—while producing harder and better work than can be done by hand, and saving time and labor.

Boring-Machine: see Boring Machines, Metal; Boring Machines, Wood; Lathe Tools, Milling Machines, Mortising Machines, and Wheel-Making Machines.

BORING-MACHINES, METAL. These are classified under: I. Horizontal Boring-Machines; II. Vertical Boring-Machines.

I. HORIZONTAL BORING-MACHINES.—*The Niles Horizontal Boring, Drilling, and Milling Machine* is shown in Fig. 1. The machine consists of a heavy column 10 ft. 6 in. high, mounted on a bed-plate of any length to suit requirements. The column is 31 in. wide on the face, and is fitted with a heavy saddle, 40 in. square, carrying the spindle. The saddle has a vertical traverse on the column of 6 ft., and is raised and lowered by a heavy screw. It is balanced by a counter-weight hung in the column. The boring and milling spindle is of hammered steel $5\frac{1}{4}$ in. in diameter. It slides in a heavy revolving sleeve, and has a traverse of 4 ft. It revolves in either direction, right or left hand, reversing by lever conveniently located, and has 8 power-feeds, ranging from $\frac{1}{16}$ to $\frac{1}{4}$ in. per revolution of spindle. It is also provided with hand-feed and quick return. The milling-feeds are six in number, ranging from $\frac{1}{12}$ to $\frac{3}{16}$ in. per revolution of spindle. These feeds are applied only to the column and saddle, and are by power only. Any of these feeds for the quick motion may be utilized to set a drill, boring-bar, or milling-cutter to work anywhere on the surface which the machine will reach. At one end of the bed-plate is placed the driving-gear, milling-feed, and quick-traversing mechanism for the column. The quick power traverse of the column has a speed of 5 ft. per minute. The driving-cone has six steps for a 4-in. belt, and is strongly back-geared, giving twelve changes of speed, ranging from 2 to 200 revolutions per minute, and has ample

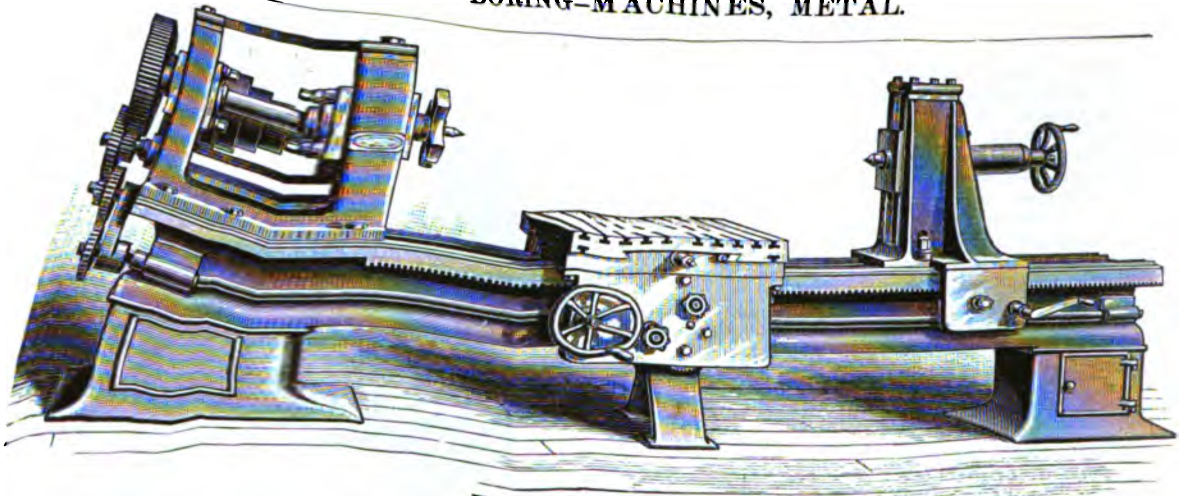


FIG. 3.—Nicholson boring-machine.

Cylinder Boring and Facing Machine.—Fig. 4 shows a machine built by Pedrick & Ayer, of Philadelphia, for boring cylinders up to 25 in. diameter. The boring-bar is solid forged steel, the screw is of steel with bronze thrust-bearings. The bar can be slipped through the bearing and gearing, or left standing, while the tail-bearing or back pedestal is taken away and the cylinder is placed in position over the bar. The feed-casing is made to feed either way, and has two changes, to operate which it is only necessary to push in or pull out a pin in center of the hand-wheel. The facing-head can be readily placed on the bar as desired, and, if necessary, can be operated at same time the cylinder is being bored. The cutter-heads have a long bearing on the bar, and are arranged for four tools, that number being found by

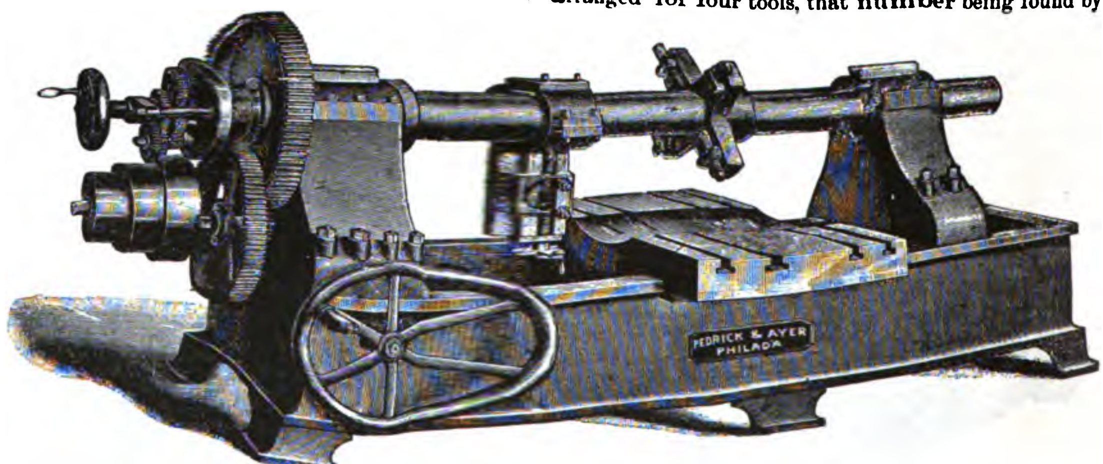


FIG. 4.—Pedrick & Ayer cylinder boring-machine.

experience the most desirable, as it distributes the stress or strain on the bar. The bed is movable on the shears, and is easily set in position by the hand-wheel at the forward end of the machine.

Duplex Boring-Machine.—Fig. 5 shows a machine built by Pedrick & Ayer for boring the two cylinders of a duplex pump at one time. The centers are made a fixed distance apart, to suit the centers of the pump-cylinders. The machine is therefore a special one, designed to be used upon but one size of pump. The platen is fed by a nut and screw driven by a 2¼-in. feed-belt.

Portable Cylinder Boring-Machines.—Fig. 6 shows a portable machine built by Pedrick & Ayer, of Philadelphia, especially adapted to boring out locomotive-cylinders in their places, by removing only one or both heads and piston. The back-head, cross-head, or slides need not be removed, unless so desired. On removing the piston and leaving the front head and stuffing-box, a small cone takes the place of the stuffing-box, and with proper adjustment at the front head the machine is ready for work; it is fed with a constant feed of cut-gears. The clamps or cross-heads are so arranged that they may be used conveniently on locomotive-cylinders of all sizes. The same bolts or studs that fasten the cylinder-head on are used to bolt

is 38 in. in diameter and 27 in. in height. The table is 36¼ in. in diameter and has twenty changes of speed. The feed is by belt and has 4 changes. The turret-head is square in form, 10 in. in diameter, with four 2½-in. holes. It will unlock automatically at any point, and is revolved by hand. The turret-slide can be set to bore or turn at any angle, and has a movement of 16 in., with trip at any point. Another form of mill by the same makers has two sliding heads. Its capacity is 37 in. in diameter and 29 in. in height. The table is 36¼ in. in diameter, and has twenty changes of speed. The feeds are automatic, and range from $\frac{1}{32}$ to ¼ of an in. in angular and vertical directions. Each head feeds independent of the other. The heads can be set at any angle, and carry the tool-bars, which have a movement of 18 in.

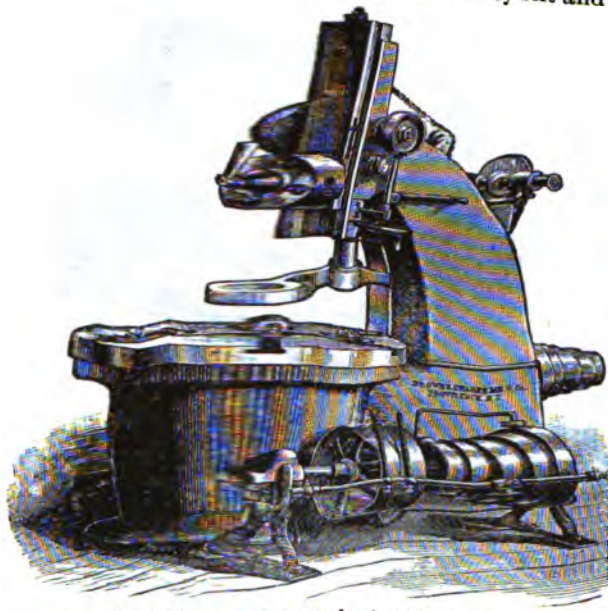


FIG. 7.—Brown & Sharpe's chucking-machine.

Chord Boring-Machine.—Fig. 9 shows a machine made by the Niles Tool Works for boring the holes in bridge-chords and I-beams. The machine is arranged with two independent heads on one bed, adjustable on the bed for varying lengths. The bed may be made of any length to suit. The two heads are complete in themselves, driven independently, and with all attachments, feeds, etc., for a complete boring-machine. The power is ample for boring four holes, punched 4 to 8 in. diameter, at one time, and the range of speed is such as to adapt the machine for drilling down to 1½-in. holes. The two columns have both power and hand movement for adjustment on the bed. The heads have 18 in. reach, boring to the center of 36 in. high. The spindle has 24 in. traverse. They will take in under the cutter work 36 in. The range of work in length is from 5 to 50 ft. between centers. The feeds are by power, and are reversible up or down, and range from $\frac{1}{16}$ to

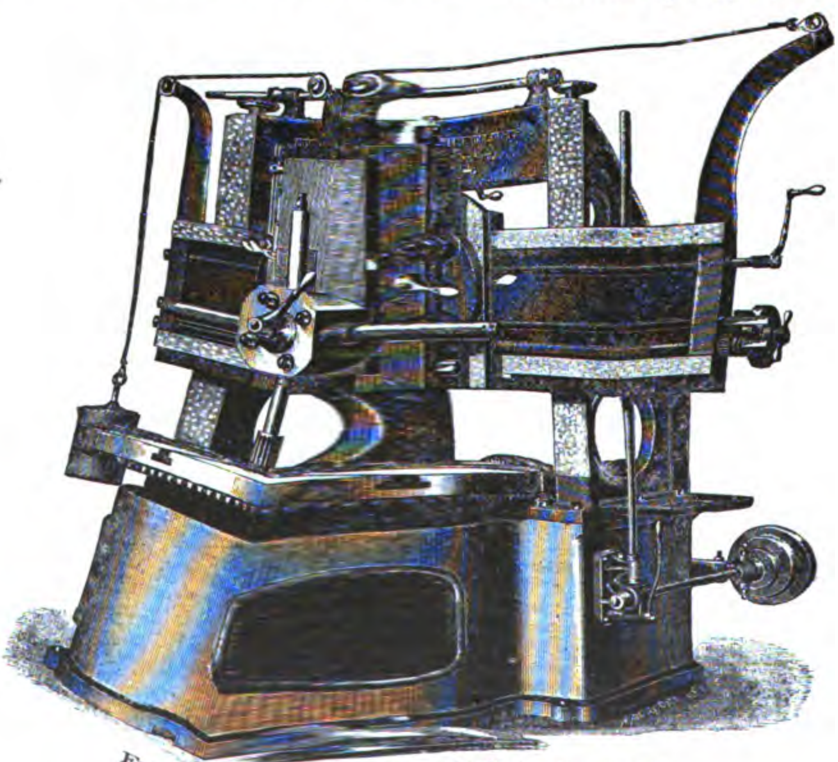


FIG. 8.—Bullard's boring-machine.

vertical adjusting screws, a slight independent adjustment is provided in the tail-block, so as to bring the boring-bar perfectly true with the bed. The driving-cone pulley has four steps, and a heavy back-gear is attached to the spindle, giving eight speeds for the bar. The spindle is fed forward by a rack and pinion having four changes of speed, is driven by a worm-gear, and may be run back quickly by hand. The main spindle is driven directly by a belt from the floor-shaft, and the head may be raised or lowered without changing the length of the belt. The principal dimensions of the machine are as follows: Length of table, 7 ft.; width of table, 3 ft.; extreme width in clear between head and tail blocks, 8 ft.; vertical adjustment of heads, 5 ft.; floor space, 10 × 15 ft.; total height, 9 ft. The weight of the machine is about 26,000 lbs.

BORING-MACHINES, WOOD. From the primitive auger to the high-speed multiple gang boring-machine of the present day is a far cry; each year sees more advance either in the speed of work, in the quality of the work done, or in its range of dimensions and position, etc., until the catalogue of boring-machines alone would comprise quite a list, and a complete description of each kind made would fill a volume of no mean size. Suffice it if we select from a long list a few of the most typical or most ingenious and special for mere mention, in addition to the descriptions of construction and operation given in the former volumes of this *Cyclopædia*. In some boring-machines the spindles are run by gearing, and in others by belting. The latter permits higher speed of the spindles and smoother running. For certain classes of long boring, as in wooden pump-tube work and the making of porch columns, the cutter is carried on the end of a hollow pipe which has a worm rotating therein to carry out the chips; this being necessary in a horizontal machine, while a vertical machine would be undesirable by reason of the great length of work required to be done. Even such a simple operation as boring holes for pins, as in sash and door work, is now performed by an attachment to the double-arm sand-papering machine; the work being done by simply pressing the hand on the string, which drives the bit into the work, and on removing the hand the spring withdraws the bit from the hole. A very convenient machine for use in small shops, or where much large boring does not require to be done, is a portable boring-machine, Fig. 1, which is entirely self-contained, and may be fastened to a post and belted directly from the line shaft. There is a vertical spindle bearing the boring-tool and driven by a mitre gear, inclosed in a box housing which carries the bar for starting and stopping, also a counterbalanced lever for bringing the auger to the work. The boring spindle passes through one of the mitre wheels, so that it may be raised and lowered while rotating. A machine intended to meet the demand for boring to the center of large pieces is built by C. B. Rogers & Co., and differs from the usual types of small single-spindle boring-machines in having its spindle at a greater distance from the vertical post, so that holes may be bored in the center of the large piece. There is a stop-rod to regulate the depth of the hole bored, and also one to control the length of throw, thus doing away with the common adjustable collar of the spindle. The spindle is balanced. The table tilts for bevel work, and may be raised and lowered by a screw and hand-wheel in front. The guide may be reversed to the front of the table. A cabinet-maker's boring-machine for two or three spindles, made by C. B. Rogers & Co., has a square column like table cast in one piece, and upon which there is a plate which bears the front boring spindle-box, which, when they show two in number, are adjustable to and from each other by a right and left hand-screw. Where there are three, the center box is stationary and the others are adjusted to and from it by the screw and crank. The rear spindle-boxes have a swiveling motion on the table to accommodate the changes in distance between the front boxes; and they are driven by an endless belt which, passing from the main driving pulley at the lower part of the machine, goes over one boring-spindle pulley, down under an idle pulley (which has vertical adjustment to take up the slack of the belt as it stretches), up over the other boring-bar pulley, and down under the main pulley. Thus both the spindles run in the same direction, and their adjustment practically makes no difference in the tightness of the belt. Each of the mandrels to which the boring-bars are attached has a universal joint between it and the spindle. The table upon which the work is placed, and which bears a fence, is adjustable vertically in slides on the front of the machine, being controlled by a screw and hand-wheel. The table also has a horizontal movement to and from the bits. One very useful type of boring-machines, especially for car-work, has three or more vertical spindles, each bearing a different-sized bit, and each having a counterbalanced lever by which it may be drawn down to the work without much effort, and may be retired when the hand is taken from the lever. In such machines, there is little or no necessity for any lateral adjustment of the distance between the spindles, as only one is used at a time; but an important feature is that the ones which bear the adjusting bits are driven at slower speeds than the others. Where they are for heavy work, the table upon which the lumber rests is furnished with four rollers, and in improved machines of this type the timber may be pushed along on the rollers

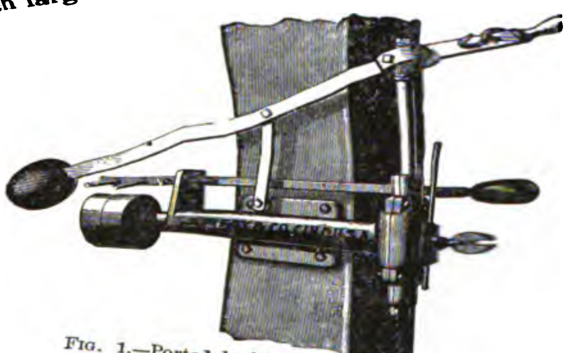


FIG. 1.—Portable boring-machine.

number of holes at one operation without the necessity of laying them out, has a table, back of which there are ranged eight arbors, each carrying a boring tool. These spindles run in frames, which are gibbed to a connected gateway, and are vertically adjustable by a screw to each. The arbors have lateral adjustment also. Beneath the table and parallel with its length there is a horizontal drum, and the belt which drives all the boring-arbors runs from this over one driven pulley, then down under the drum, up over the second driven spindle, and so on until it has passed over all the pulleys; then it passes back lengthwise of the table by guide pulleys, so that there is but one belt to be laced, and no difficulty as in maintaining eight separate belt tensions. The spindles being set at the proper distance apart and at the proper heights, no adjustment is necessary. Eccentric clamps on the table hold the work. The table has lengthwise traverse on V-slides by a hand-lever.

The Bentel and Margedant Rake-Head Boring and Routing Machine has 20 spindles, which can be adjusted laterally to the required distance apart. The work is clamped to the table by four eccentric clamps, the handles of which are in the front of table, standing straight up. These clamp the work against a fence, which is bolted to the top of the table by T-slots. The face of this fence is lined with wood, so as to protect the points of the bits when cutting through.

The table is balanced, and has a continuous vertical reciprocating motion given by a crank and double levers in front of the machine. The crank has an adjustable throw to vary the length of mortise, and is driven by means of the pulley shown at the extreme right of the machine. The connecting rod also has an adjustment to bring the mortises into any position on the stick. The feed is operated by means of double lever and two vertical rods. These rods connect with two right and left ratchet-pawls, thus producing a continuous feed, which may be varied to suit the requirements of the work. The table is fed in by racks and pinions, and is geared at four points to get a parallel movement.

In operation, the work is clamped to the table, which keeps up its vertical reciprocating movement, and is not stopped to place the work. The feed is then thrown in by lifting a hand-wheel in front; this engages a worm and gear which feed the table forward automatically, until it has traveled in against an adjustable stop, when the feed is tripped off and the table returns automatically by means of a weight, and is ready for another piece. The machine is claimed to make 1,200 mortises 1¼ in. long through 1 in. hard wood in an hour, leaving the mortise smooth and free from chips. It can be arranged for making a tapering mortise or to mortise lengthwise of the material. The makers state that it has mortised 150,000 holes through 3-in. sugar lumber without breaking a bit. For use as a multiple boring-machine, augers are substituted for the routing bits; the feed-belt at the right is stopped, and the one at the left which drives the cone is started, and the work clamped to the table, the same as for routing. The table is fed forward by pressing a foot-treadle; this is accomplished by a pair of driven friction-rolls, which grasp the slack belt which is wound around a pulley in front. When the pressure is removed, the table returns by means of the weight formerly described, which comes below the floor. The machine, when once adjusted for any particular piece, will turn out any number, all alike, without laying off.

Boxing Machine: see Wheel-Making Machines.

Box Tool: see Screw Machines.

BRAIDING AND COVERING MACHINES. Braiding machinery is employed for making round, plaited fabrics, either flat or round, such as are used for braids and fish-lines, other trimmings, wicks, curtain-cords, shoe and corset laces, cords, etc. It has also of late years found a very important employment in the manufacture of the covering for electrical wire. The general principle of braiding machines follows closely the idea of the old May-pole dance, in which each of the dancers, holding a ribbon attached to the top of the pole, moved around one another, in and out, until the ribbons were braided or plaited down the length of the pole. The various strands of the braid or covering are applied to a wire or core by mechanism, which imitates substantially the movement of the dancers. Covering or armoring machines are used on applying the non-braided insulating envelope of electric conductors.

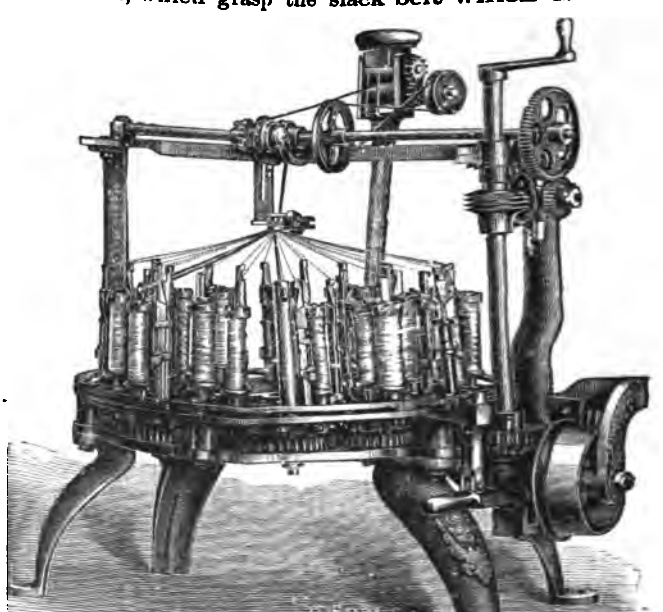


Fig. 1.—Braiding-machine.

loose pulley being chambered and filled with wool to retain the oil for lubricating. The wire then passes up through the disk on which the flier is fastened, with a counterbalance opposite. The spool is placed on the spindle, and the thread carried from it to the flier and under the drop-wire of the stop-motion, then up through the eye of flier to the winding-point, where it is fastened to the wire coming up through the spindle, in the top of which is the grooved guide and support for the wire when being wound. The guide can be finely adjusted for more or less tension and for the *lay* of the thread. The revolutions of the spindle which carries the spool and the flier around the wire at a high speed cover it uniformly and with the smallest fraction of insulation. Hanging over the thread and in the bottom of the flier is the drop-wire, which, when the thread breaks, or a spool runs out, drops, and extending through the disk, in its revolutions comes in contact with a latch holding up the starting lever, releasing it, when it falls, changing the belt to the loose pulley and stopping the spindle, each spindle being independent. The spool is slotted, and when it runs out of thread is raised just above the spindle and taken off sidewise; the wire passing through the slot, a full spool is taken down from the spool-holder above and placed on the spindle and threaded up, when the spindle is ready to go on again. The wire passing up through the tube or spool-holder passes around the feed-wheel and over the sheave down on to the reel. The feed-wheel is driven by connections of shaft and gearing with the spindle, making it positive; a variety of changes of speed being obtained by change-gears, which is made by a simple and quick arrangement. The hand-nut at the left of the feed-wheel is loosened, the wheel is raised up, throwing the gears out of mesh, and, after the change is made, the wheel is dropped back to engage with the gears. The hand-nut on the right of feed-wheel, when loosened, releases the wheel from the gear, and allows it to turn back to repair the wire or to mend a break.

BRAKES. *The Westinghouse Quick-Action Automatic Brake.*—In 1886 a practical test was made upon a train of 50 freight cars, to determine the applicability of existing brake apparatus to such a train service. This test was made upon the Chicago, Burlington & Quincy Railroad, under the direction of the Master Car-Builders' Association. It established the fact that, when the brakes were applied from the locomotive with full force, the reduction of air pressure in the train brake-pipe progressed gradually from the forward to the rear part of the train, causing the application of the brake upon the fiftieth car seventeen seconds later than that upon the first car. The retarding effect of the brakes applied to the forward cars, accumulating as it passed backward toward the unretarded rear of the train, was to close up the space between consecutive cars (due to lost motion in the couplings and compression of the draw-springs), and to produce severe and injurious shocks upon the rear cars and their lading.

It became evident that, to avoid such shocks and to give satisfactory results in this class of railway service, the application of the brakes upon successive cars must occur at such a rapid rate that no considerable retarding effect of the brakes shall be produced upon the forward part of the train before the brakes are in action at the rear end of the train. Experiments made by the Westinghouse Air-Brake Co., in the development of the quick-action brake, demonstrated that, with the closed coupling between cars and springs of such elasticity as those commonly employed in the draft-gear of freight-cars, shocks at the rear end of the train, of such magnitude as to injure cattle, could not be prevented, if the interval of time between the applications of succeeding brakes exceeded ·05 second; or the brake upon the fiftieth car must be applied not later than about 2·5 seconds after the application of that upon the first car. These conditions are fulfilled by the quick-action automatic brake, by the use of which the brakes upon 50 freight-cars may be successively applied in 2·25 seconds, or with an interval between the applications of succeeding brakes of but ·045 second.

The controlling element in this system is a discharge of air from the train brake-pipe at each car, by the operation of the triple valve, to cause the operation of the triple valve upon the next succeeding car; that is, a quick discharge of air from the train-brake pipe (either through the engineer's brake-valve, by the engineer, or at any point in the train), causing the nearest triple valve to operate, the others are successively operated by repeated discharges of air from the train brake-pipe, each triple valve responding to the discharge through the next preceding. The length of the main train brake-pipe, upon a train of 50 freight-cars, is 1,900 ft. The remarkable results attained, in the application of the quick-action automatic brake, will be appreciated when it is remembered that the elasticity of dry atmospheric air permits the propagation of an impulse or vibration, under the most favorable circumstances, only at the rate of 1,090 ft. per second. Sound—a most perfect example—requires 1¾ seconds to travel unimpeded through the atmosphere a distance of 1,900 ft. Yet the quick-action brakes are applied by an impulse which actuates a piece of mechanism, which in turn produces a second impulse, which actuates a second piece of mechanism, and so the impulse is repeated forty-nine times and caused to travel 1,900 ft., against the retarding influences of a comparatively small pipe, having a sinuous course and a vast number of irregular shapes and sharp turns, in the inconceivably short time of less than 2¼ seconds, or with a velocity 80 per cent of that of sound. Such results have been attained through a slight modification of the triple valve of the plain automatic brake (by which name the former Westinghouse automatic brake is now known), with the addition of a few supplementary parts. These modifications are such that they alter in no respect the functions performed by the triple valve of the plain automatic brake, and the additional parts operate only when a quick stop of the train is required.

Two distinct characters of performance of the triple valve may thus occur, the selection of

spring 22 may be compressed by a comparatively small difference in the air pressures upon the sides of the piston 5, a small reduction only of air pressure in the train brake-pipe, if quickly made, occurs before it is given access to the brake-cylinder through the check-valve 15. In all other respects the quick-action triple valve operates in the same manner as the plain automatic triple valve.

The triple valve is secured to and communicates directly with the auxiliary reservoir, while the pipe *b*, passing through the reservoir, affords communication between the triple valve and the brake-cylinder. The piston-rod 3 is a hollow tube, in which is inserted a rod having a

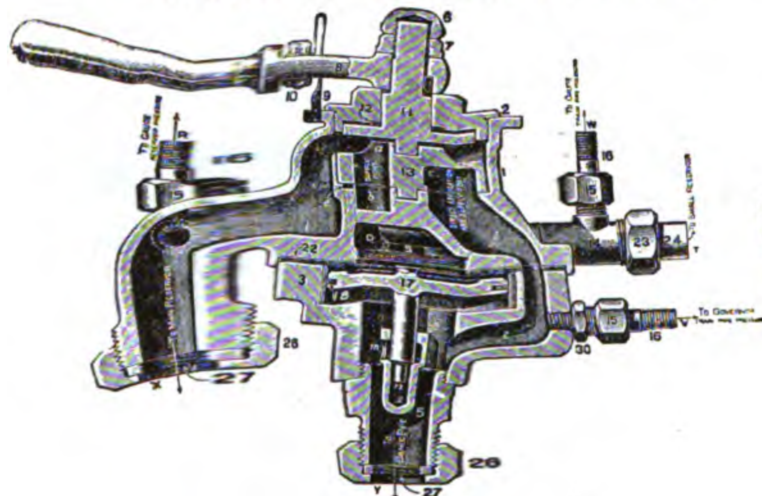


FIG. 2.—Brake-valve—Section.

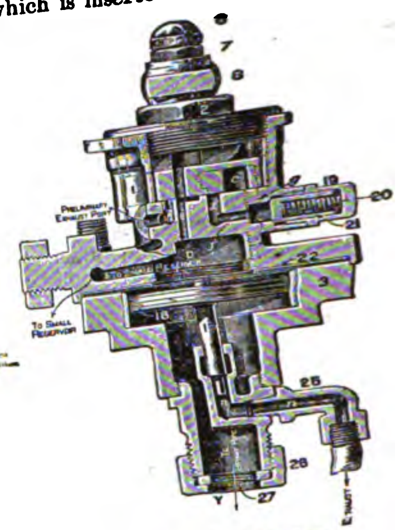


FIG. 3.—Brake-valve.

clevis at its outer end, which is attached to the lever. Its outward movement applies the brake.

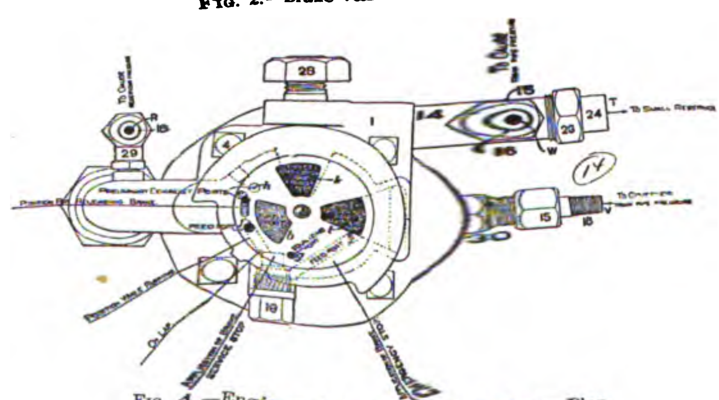


FIG. 4.—Engineer's brake-valve—Plan.

The Engineer's Brake-Valve.—This valve has four distinct functions: First, to establish direct communication between the main storage reservoir and the train brake-pipe, for releasing the brakes; second, to maintain the required air pressure in the train brake-pipe and auxiliary reservoirs, while also maintaining a certain greater pressure in the main reservoir, to make sure the release of all the brakes after an application; third, to permit the escape of air from the train brake-pipe at a fixed rate, for all ordinary applications of the brakes; fourth, to cause a rapid discharge of air from the train brake-pipe, to secure the quick-action in an emergency application of the brakes. Figs. 2, 3, and 4 illustrate the brake-valve. The pipe from the main reservoir is attached at *X*; the train brake-pipe at *Y*; at *T* a small reservoir is attached, which merely serves the purpose of giving increased volume to the chamber *D*. A rotary valve 13 (the lower face of which is shown in Fig. 8) is operated by the handle 8. The piston 17, having a stem formed into a valve at its lower end, is subject to the air pressure of the train brake-pipe upon its lower face and to the air pressure of chamber *D* upon its upper face. The rotary valve 13 has two ports, *a* and *j*, passing through it, and two cavities, *c* and *p*, in its lower face. The seat for valve 13 has a cavity *b*, a large port *k* and a small port *h*, both leading directly to the atmosphere, two ports, *e* and *g*, leading to the chamber *D*, a large port *l*, leading to the train brake-pipe, and a port, *f*, leading to the port *l*, and in which is a valve 21. The different positions for the handle 8 are defined by projections from the valve-casing, shown in Fig. 4, which are encountered by the spring 9 from the handle, and offer sufficient resistance to the movement of the handle to mark the positions.

The operation of this valve is as follows: The handle 8 being placed in the release position, the air passes from the main reservoir, through the port *a*, cavities *b* and *c*, and port *l*, to the train brake-pipe, and releases the brakes. At the same time the air also passes through the ports *j* and *e* to the chamber *D*, thus placing piston 17 in equilibrium. The handle 8

any degree of tempered clay. The means of relief in cases of stones or other obstructions consist in doors, shown in front of the press, which are held in place by springs, so adjusted that if an obstruction projects from any single brick that door will fly open and allow it to pass out, leaving the remaining five bricks in the mold perfect, or if the obstruction covers more than one brick it will open two or more doors and pass out. This arrangement prevents breakage and wear and tear on the molds. On the side of the machine just above the grip connection is a dash-pot with its plunger connected with the ejector-lever, which forms an air-cushion, to prevent jar on the return stroke. The mold-table is held in position by four

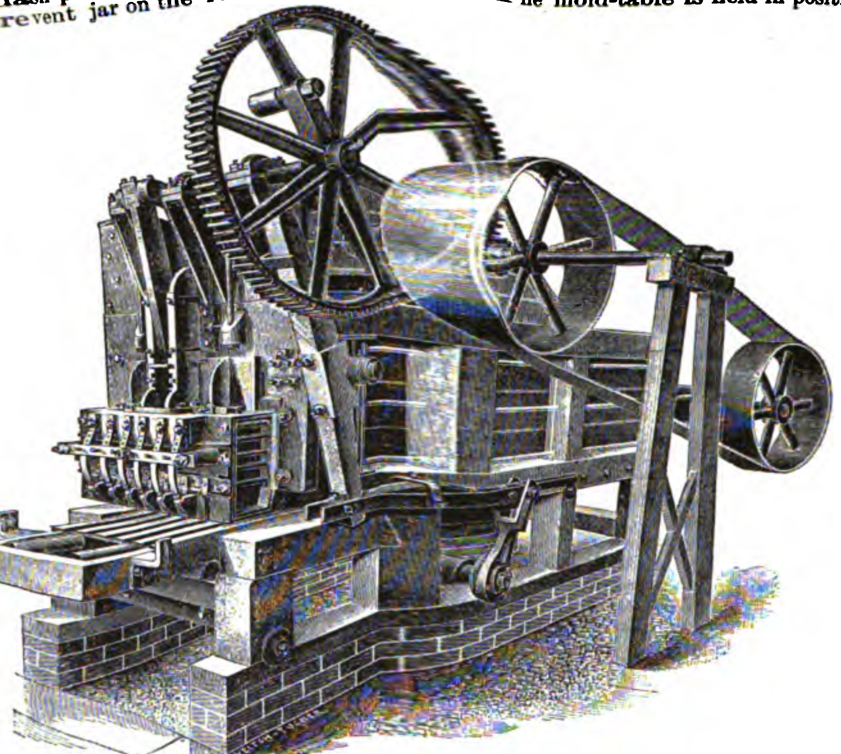


FIG. 1.—The New Haven brick-machine.

large steel screws that work in heavy iron cross-beams. The ejector-carriage is of iron, with wood buffer strip on the front to protect the molds from wear. Its four rollers run on an iron track on table. The carriage has a quick return motion, which allows plenty of time to insert the molds. Weight of machine, complete, is about 14,300 lbs., or a little more than 7 tons. In point of capacity, the machine is usually geared to make 13 molds per minute, which is 4,680 bricks per hour. For an output of 13 molds per minute the main driving shaft should run about 150 revolutions per minute. With stiff clay the power required for this output is about 25 horse. To produce 40,000 bricks per day requires a force of nine men and four boys.

The Chambers Brick-Machine (Fig. 2), manufactured by Messrs. Chambers Bro. & Co., of Philadelphia, Pa., is an example of an auger-class of stiff-clay machine. The clay is taken direct from the bank and dumped on the platform covering the machine at the side of a galvanized iron hopper that leads into the tempering-case of the machine, and mixed, when necessary, with loam, sand, or coal-dust; and the requisite amount of water being added to temper the clay to the proper consistency, the mass is shoveled into the hopper and falls into the machine. The hopper of the brick-machine proper is square, with circular corners, to prevent the clay from sticking in the corners, and is larger at the bottom than at the top, to prevent jamming of the mass. It enters the tempering-case at one side of its center line, so that the clay in falling meets the revolving tempering-knives as they are coming up. This keeps up an agitation of the clay in the hopper, and tends to prevent clogging and an irregular supply of clay to the tempering device. A small cast-iron roller is situated at the bottom of the hopper, and just above the line of tempering-knives and at the side toward which the knives move. Against this roller the clay is thrust by the tempering-knives as they cut through the solid mass of fine clay and lumps, and on to which the clay adheres; but as this roller turns around, say once in a minute, the impinged clay is carried within the path of the knives, and is carried off by them and tempered, thus effectually clearing the throat of the hopper. The tempering portion of the machine consists of a cast-iron conical case, in which revolves a horizontal shaft into which are set spirally, strong tempering-knives.

ocity through all its parts. As the channel of a river flows faster than the or those near the banks, so does clay move through a die, the friction of g them back, while the center moves more freely. In the present machine vercome by the peculiar "former," which is so shaped as to facilitate the o the corners, and retard it opposite to the straight sides of the die, the pro- uch larger opposite the larger diameter of the die (Fig. 3). For very wide he resisting projection is omitted wholly at the short diameter of the die, or bricks, the spreading of the clay outward to the edge, rather than into the g facilitated. By this means the angles of the bar of clay are re-enforced lid and sharp, thus insuring square and well-defined corners to the bricks. secured to the screw-case by a hinge and swinging bolt, so that it may be

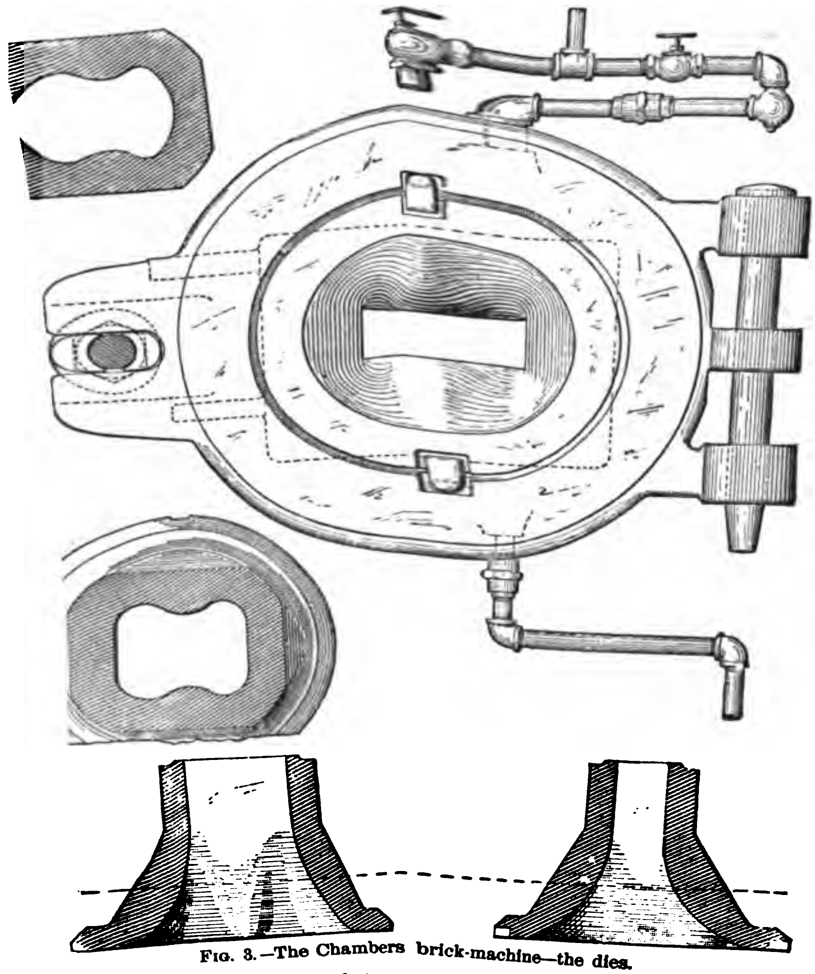


FIG. 3.—The Chambers brick-machine—the dies.

pen for the removal of stones. This swinging bolt is secured to the case by fficient strength to hold under normal conditions, and when undue strain l clay, etc., it yields, thus forming a safeguard against accidents arising from g.

clay issues from the forming-die it passes through a small chamber filled nd, which adheres to the surface of the bricks. The surplus sand is kept mber by swinging elastic scrapers, which allow the bar to escape with its This sanded surface of the clay bar prevents the bricks from sticking barrows or in the hacks, or on the drying-cars, and improves them in color clay has more or less stones in it, and as it is impracticable to pick them all out, ity of making some provision for their removal. If a stone is more than 3 in. does not lodge in the stationary lining of clay in the case, it will lodge at the xpressing screw, preventing the clay from issuing at the die, when a safety- open, through which the stone may readily be removed. If a stone of less

›acity, 40,000 bricks per 10 hours; estimated weight, 12,000 lbs.; speed ; 145 revolutions per minute; pulleys, 42 in. diameter, 10 in. face; ma- 12 to 1.

e in this machine, all shapes and sizes of bricks, especially those of orna- be made. The construction and arrangement of the die, therefore, form

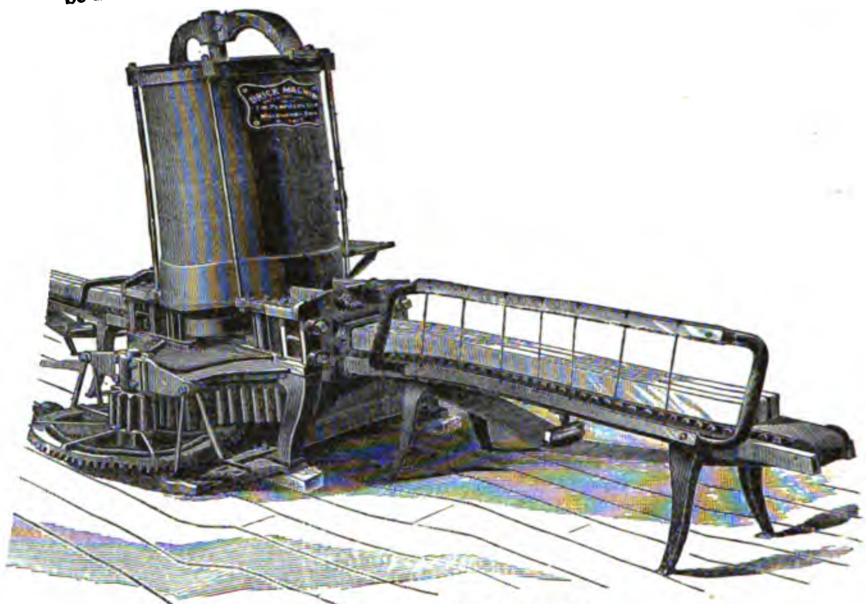


FIG. 5.—The Penfield plunger brick-machine.

d important feature. The back or forming die receives and forms a bar of clay led corners. The clay bar then passes through the finishing die, which is slightly ·nered, and by means of this "slicker" and the process of lubrication the bar is nd given corners accurately shaped. The lubrication is effected by water, by steam, h. For water lubrication the finishing die is set a short distance ahead of the back die, and water (or oil) is allowed to flow between the two dies and upon the clay bar. For steam lubrication the finishing and forming dies are bolted tightly together and packed. Steam is then supplied directly from the boiler to the clay bar. In cases where both water and steam lubrication are desired, two slickers or finishing dies are used, the one next to the forming die being arranged for steam connection, and the front slicker being water lubricating, each being operated respectively as already explained. Good results have also been obtained with a so-called "brass scale finishing" die in which the outer part of the slicker is an iron casting, into which is fitted a wooden lining, which in turn is lined with strips of spring brass. This slicker is provided with a large number of channels, conducting the water or steam from the outside of the slicker to the brass scales, thus lubricating the bar of clay effectively as it passes through the die. In still another form of die each corner of the bar of clay is lubricated separately, and by means of a brass plug at each corner the flow of steam can be regulated or entirely shut off from any one or more corners at any time desired. Thus, if one corner of the die becomes clogged, so that the steam does not reach the corner of the bar of clay, causing it to ruffle or tear, the steam can be shut off from the other three corners. This will ıllow the full head of steam to reach the corner which is clogged, blowing out the obstruc- ion.

FIG. 6.—Hand brick-repressing press.

ls are rubbed with sand also (Fig. 8). Now they are wheeled to the "press-shed," y are "hacked" close; that is, so as to prevent the air from passing between them, eeping them at about the same consistency as when they were made, which is just repressing. From this close hack the bricks are taken and repressed in the usual or, if a sufficient number of presses be used, or the machine runs slow, they may be l pressed direct from the barrows. This repressing brings the bricks to a mathemat- ision as regards their size, surfaces, and angles, the flat or largest surface of the bricks ncave, for the purpose of allowing the edges to come close, so as to show a very thin en laid. We do not think the "skin" on the press-bricks molded in our machines o good as those molded in sand by hand; but where the clay gives "color," and not fing sand, then the best color is obtained by repressing our machine-bricks direct from hine."

ngement of Brick-Yard Machinery.—Fig. 9 represents a ground-plan, showing the nent of pits, single-worker machine, boiler and engine, etc. This plan is made to e arrangement of pits and machines, where crusher and elevator are used, or where it

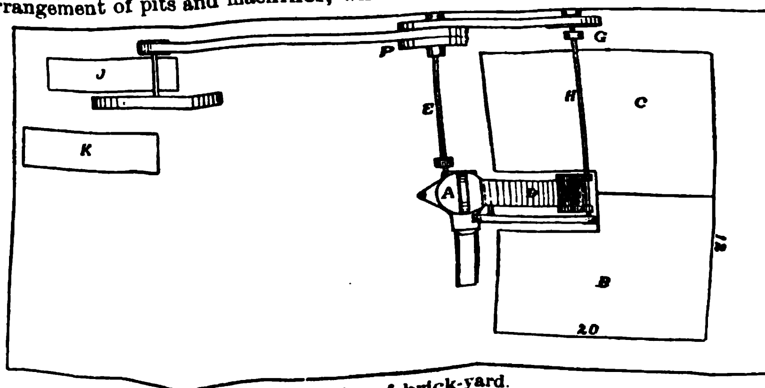


Fig. 9.—Plan of brick-yard.

and desirable to simply use the elevator. *A* represents the machine placed midway en the pits *B* and *C*. The pits are 12 ft. long and 20 ft. deep. The clay-crushers are l between the two pits, and about half-way back. By this arrangement the clay is rs reasonably convenient to the clay-crusher, and one pit can be filled and soaked while ther pit is being run into brick. This is by far the best plan upon which to operate the ine. The machine does not in this case require moving, and the clay can be much more ughly soaked, and fed into the crusher with less labor and expense than it can be thrown the machine. One man can feed the crusher as easily as two can feed the machine. re a crusher is not used, an elevator, represented by *D*, is arranged to run over the tion between the pits. As the pits are 12 ft. wide and 20 ft. long, the shovelers are never great distance from the carrier, and the saving of one man's labor can be effected by this ngement, which will pay for an elevator, or even a crusher, in a very short time. *E* esents the tumbling-rod which transmits the power to the machine. At *P* the pulleys placed, which receive the belts from the engine *J*. *K* represents the boiler, and *G* the her pulley. *H* represents the pulley-shaft to the crushers. These pits, boiler and engine, can all be covered by a shed, 30 × 50 ft. Where parties do not use the elevator, it is nd desirable to make the pits, instead of 12 ft. wide and 20 ft. long, 20 ft. wide and 12 ft. g. In this case the machine is placed in the center of each pit, and moved from one to the er. This is to facilitate getting clay to the machine, as in no case will the clay be at a ater distance than 12 ft. from the machine.

Drying Bricks.—Fig. 10 represents Chambers Bro. & Co.'s artificial drier. This drier nsists of six or more brick flues, about 40 ft. long, 8½ ft. wide, and 4 ft. high, built of bricks, h a railroad track through each, slightly descending from the machine, with fire-grates and ors at the lower end and a stack at the upper end. From the grates, upon which coal, coke, wood is burned, the results of combustion are conveyed along in a flue under the bottom the track to near the stack end, and are allowed to escape therefrom gradually, through rforations or slots, up, under, through, and between the bricks on the iron cars. For each nnel there are two chambers for the admission of air, one on either side of the grate com- rtment, which enter the conveying-flue just back of the grate surface. In addition to the ses from combustion, a large amount of air is admitted over and at the sides of the furnace to the flue, which becomes heated, and, when distributed through the bricks by the adjust- le flue, takes up the moisture from the bricks and carries it off through the stack. The oportion of air to the results of combustion is regulated by swinging dampers, while the ift of the fire is under independent control by the ash-pit doors.

The bodies of the cars used with this drier are made of wrought channel-iron, a rigid en framework, on which the pallets are piled. A boy can transport 504 bricks on one of m.

The "pallets" consist of two strips of wrought channel-iron secured at either end to a idle whose height is greater than the width of the brick. These handles are so constructed

been emptied takes its place. The loaded car is then run on to the transfer-car, and into any one of the flues, where a current of heated air (an artificial summer breeze) is

FIG. 11.—Brick-truck.

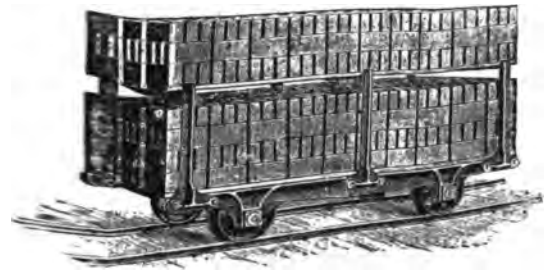


FIG. 12.—Dry brick-car.

FIG. 13.—Dump-table.

FIG. 14.—Brick-barrow.

ed through them, the steam from the bricks near the fire condensing on the surfaces of cold ones and preventing checking or cracking, while the bricks absorb the heat from the steam and commence drying from the inside first. When the bricks directly over the fire are dry, the car is run out to the kiln to be set, a fresh car being put in at the upper end, pushing the others down and bringing another partially dry car immediately over the fire, and so on. It is claimed that one ton of anthracite coal will thus dry 25,000 bricks; hence the expense of artificial drying is less than that of sunshine.

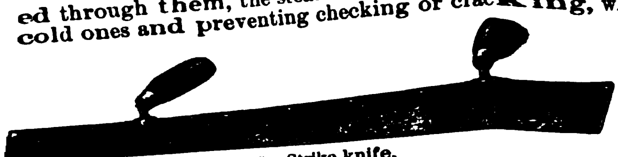


FIG. 15.—Strike-knife.

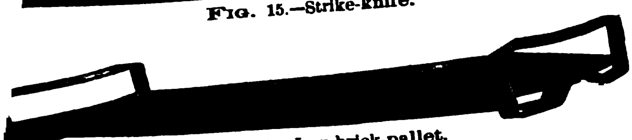


FIG. 16.—Iron brick-pallet.

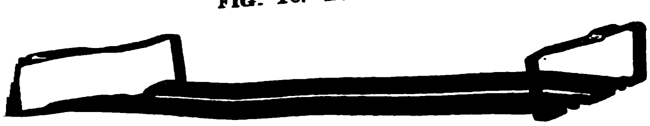


FIG. 17.—Steel brick-pallet.

Figs. 11 to 17 represent a variety of improved brick-yard appliances. Fig. 11 is a platform spring-truck suitable for handling green bricks when placed upon pallets. Fig. 12 is a double-decked dry car, on which the bricks are hacked four courses high on the lower deck and three courses high on the upper deck. Fig. 13 is a revolving dump-table. Fig. 14 is a barrow designed for wheeling green or burned bricks. Fig. 15 is a brickmaker's strike-knife. Fig. 16 is a wrought-iron interlocking pallet for stiff-tempered bricks; and Fig. 17 is a steel pallet for bricks molded on flat side, or for those stiff enough to stand on edge.

Broach, Channeling: see Quarrying Machinery.

BROACHING-MACHINES. *Nicholson & Waterman's Broaching-Machine.* — Figs. 1 and 2 show a broaching-machine built by Nicholson & Waterman, Providence, R. I., arranged for milling the sides of nuts and bolt-heads. The cutters consist of straight mills, with teeth set angling and slightly hooking. Two sides are finished at one pass. The cutters are set in a swivel-head, and approach each other at the bottom. The head swings from under the plunger to facilitate the entering of work. Guide or holder blocks secure the uniformity of angle, centralization of bolt-head or nut, and serve as a gauge for uniform size. The action of the plunger is automatic in its return. A rotary pump feeds lubricant upon the work from a tank placed under the working top. The principle upon which the cutting is done is that of a shaving or drawing cut. The nut or bolt is forced down between the mills, and is guided centrally. The time occupied in milling two sides is about four seconds; for

Then

$$m = \frac{1}{l}\left((H - t') - \frac{W}{w}(t' - t)\right).$$

(2) $$Q = 1 - m.$$

(3) When A or m is minus. $$s = -2{\cdot}0833\,A.$$

(4) Averaging several experiments. $$m = \frac{\Sigma A}{n\,l}.$$

(5) $$s = -2{\cdot}0833\,\frac{\Sigma A}{n}.$$

(6)

In the use of the barrel calorimeter the weight of the water, before and after condensing the steam, requires to be determined with accuracy. An error of ¼ lb. will cause an error of 3 per cent in the result.

Coil Calorimeter.—The following is a description of a calorimeter designed by William Kent, in which some of the probable errors of the ordinary barrel calorimeter are lessened: A surface condenser is made of light-weight copper tubing, ¾ in. in diameter and about 50 ft. in length, coiled into two coils, one inside of the other, the outer coil 14 in. and the inner 10 in. in diameter, both coils being 15 in. high. The lower ends of the coil are connected by means of a brazed T-coupling to a shorter coil, about 5 in. long, of 2-in. copper tubing, which is placed at the bottom of the smaller coil, and acts as a receiver to contain the condensed water. The larger coil is brazed to a ¾-in. pipe, which passes upward alongside of the outer coil to just above the level of the top of the coil and ends in a globe-valve, and a short elbow-pipe which points outward from the coil. The upper ends of the two ¾-in. coils are brazed together into a T, and connected thereby to a ¾-in. vertical pipe provided with a globe-valve, immediately above which is placed a three-way cock, and above that a brass union ground steam-tight. The upper portion of the union is connected to the steam-hose, which latter is thoroughly felted down to the union. The three-way cock has a piece of pipe a few inches long attached to its middle outlet and pointing outward from the coil. A water-barrel, large enough to receive the coil and with some space to spare, is lined with a cylindrical vessel of galvanized iron. The space between the iron and the wood of the barrel is filled with hair-felt. The iron lining is made to return over the edge of the barrel, and is nailed down to the outer edge so as to keep the felt always dry. The barrel is furnished also with a small propeller, the shaft of which runs inside of the inner coil when the latter is placed in the barrel. The barrel is hung on trunnions by a bail by which it may be raised for weighing on a steelyard supported on a tripod and lifting lever. The steelyard for weighing the barrel is graduated to tenths of a pound, and a smaller steelyard is used for weighing the coil, which is graduated to hundredths of a pound. In operation the coil, thoroughly dry inside and out, is carefully weighed on the small steelyard. It is then placed in the barrel, which is filled with cold water up to the level of the top of the globe-valves of the coil and just below the level of the three-way cock, the propeller being inserted and its handle connected. The barrel and its contents are carefully weighed on the large steelyard; the steam-hose is connected by means of its union with the coil, and the three-way cock turned so as to let the steam flow through it into the outer air, by which means the hose is thoroughly heated; but no steam is allowed to go into the coil. The water in the barrel is now rapidly stirred in reverse directions by the propeller and its temperature taken. The three-way cock is then quickly turned, so as to stop the steam escaping into the air and to turn it into the coil; the thermometer is held in the barrel, and the water stirred until the thermometer indicates from five to ten degrees less than the maximum temperature desired. The globe-valve leading to the coil is then rapidly and tightly closed, the three-way cock turned to let the steam in the hose escape into the air, and the steam entering the hose shut off. During this time the water is being stirred, and the observer carefully notes the thermometer until the maximum temperature is reached, which is recorded as the final temperature of the condensing water. The union is then disconnected and the barrel and coil weighed together on the large steelyard; the coil is then withdrawn from the barrel and hung up to dry thoroughly on the outside. When dry it is weighed on the small scales. If the temperature of the water in the barrel is raised to 110° or 120°, the coil will dry to constant weight in a few minutes. After the weight is taken, both globe-valves are opened, the steam-hose connected, and all of the condensed water blown out of the coil by steam allowed to blow through the coil freely for a few seconds at full pressure. When the coil cools it may be weighed again, and is then ready for another test. If both steelyards were perfectly accurate, and there were no losses by leakage or evaporation, the difference between the original and final weights of the barrel and contents should be exactly the same as the difference between the original and final weights of the coil. In practice this is rarely found to be the case, since there is a slight possible error in each weighing, which is larger in the weighing on the large steelyard. In making calculations the weights of the coil on the small steelyard should be used, the weights on the large steelyard being used merely as a check against large errors. It is evident that this calorimeter may be used continuously, if desired, instead of intermittently. In this case a continuous flow of condensing water into and out of the barrel must be established, and the temperature of inflow and outflow and of the condensed steam read at short intervals of time.

The Barrus Universal Steam Calorimeter.—This instrument was devised by George H.

…compute the amount of moisture from the loss of temperature shown by the …number of degrees of cooling of the lower thermometer N is divided by a …nt, representing the number of degrees of cooling due to 1 per cent of moist… …fficient depends upon the specific heat of superheated steam, which, according …xperiments, is 0·48. In other words, the heat represented by 1° of superheat… …thermal unit. The author's experiments show that this quantity can not be …y to the form of instrument under consideration. The quantity to be used …at according to the degree of moisture. For an instrument working under a …f 314° by the upper thermometer, and with a cooling by the lower thermometer …241°, the quantity was found to be about 0·42. When the cooling, however, was …225°, the quantity to be used was found to be about 0·51. …iments have not as yet covered a sufficient range to determine the exact law …applied to every case, but it seems probable that the specific heat is more or less …l the temperature by the lower thermometer approaches the point of saturation …ressure steam, while beyond this point the specific heat rapidly increases. For …it is assumed that the quantity 0·42 is the proper one to apply whenever the …by the lower thermometer is above 235°, and that in cases where the temperature …the quantity is to be used as an increasing one, reaching perhaps to 0·55 when …ure drops to 220°.

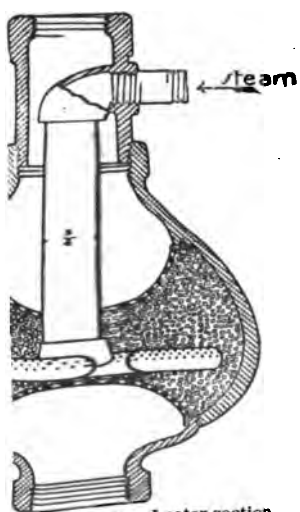
…ent of moisture, now, represents the quantity of heat determined by multiplying …at of 1 lb. of steam, having a pressure corresponding to the indication of ther… …by 0·01, and this product is to be divided by 0·42 (provided the lower temperature …235°), in order to express it in terms of degrees of superheating. For example: …ometer M shows 312°, the latent heat is 8·94 thermal units, and 1 per cent of this …ling by 0·42, the number of degrees of superheat corresponding to 1 per cent of …ound to be 21·3. For several other temperatures, which cover the ordinary range …ommonly be used, the necessary coefficient is given in the following table:

…y …M.	Coefficient.	Temperature by thermometer M.	Coefficient.	Temperature by thermometer M.	Coefficient.
[illegible]	22	310°	21·3	350°	20·6
[illegible]	21·8	320°	21·1	360°	20·5
[illegible]	21·7	330°	21		
[illegible]	21·5	340°	20·8		

…ft: see Elevators.
…see Ordnance.
…e: see Brakes. **Car-Brass Grinder:** see Grinding Machines. **Cars, Rail…** …ilroad Cars. **Car-Wheel Lathe:** see Lathes, Metal-Working.
…Cotton-Spinning Machinery.

…ATING. Car-heating, in the general acceptance of the term, has come to mean …f railway-cars by the use of steam from the locomotive. It is also technically …ontinuous heating.

…ningler System of the Consolidated Car-Heating Co., of Albany, N. Y., de… the direct action of the steam upon the water of circulation, caused by the steam discharging within the body of the water itself. The contact of the steam and water takes place within the pear-shaped body of the commingler proper, a sectional view of which is shown in Fig. 1. The flow of steam is broken into hundreds of small jets within a body of quartz pebbles in such a manner as to silently force the water through the commingler after imparting to it the entire heat of the steam. By giving the proper form and direction to the steam-jets within the commingler, a forced as well as a gravity circulation is readily obtained, and it is the addition of this feature of forced circulation which enables the commingler to move the water through such large circuits. Any amount and distribution of piping that may be found desirable can therefore be made in a car, the capacity of the commingler being fully assured. With the commingler the heating system is kept constantly filled from the condensation which takes place within the commingler, and thus water in the expansion-drum is always level with the top of the overflow-pipe. Five lbs. steam-pressure in the train-pipe at the car is claimed to be sufficient to heat the largest car in the coldest weather. Experiments conducted under the supervision of the New York Central Railroad showed that circulation was rapidly established by the commingler with 1¼ lbs. of steam.



…mmingler heater-section.

…ningler Storage System.—A small commingler, as shown in the cut, is placed …ldle seats on each side of the car, between the floor of the car and the sheathing.

Salt-water usually constitutes the circulating medium in this system, which water has a freezing-point of about 10° above zero. When solutions of salt, giving a lower freezing-point, are used, the excess of salt is liable to deposit in the circuit within the coils of the drum and the heater, and so to greatly reduce the effectiveness of the heating apparatus.

The Disk-Drum System is a modification of the coil-drum above described. A series of bronze castings made in the form of hollow disks take the place of the coil within the drum. The disks are 12 in. in diameter, and are securely screwed together at their centers. Eight strong studs are cast midway between the center and the circumference of each disk, for the purpose of binding its walls together. These studs are necessary to give sufficient strength to withstand the enormous pressure liable to come upon the circulating pipes when fire is used in the heater. All disks are tested at 500 lbs. per sq. in. Five disks are usually employed in each drum, although seven disks are sometimes used. Each disk is ribbed or corrugated, and has 2 sq. ft. of heating surface, so that the heating surface in each drum varies from 10 to 14 sq. ft., depending upon the number of disks employed. This construction allows a large amount of heating surface to be put into a compact form, and also presents a very small internal resistance to the flow of water through the disks. The drum itself is made of cast iron, to which a cast-iron head is bolted.

Two drums thus constructed are connected with the heating circuit of each car at its lowest point (see Figs. 2 and 3). They are placed so as to form the risers from the cross-over pipes,

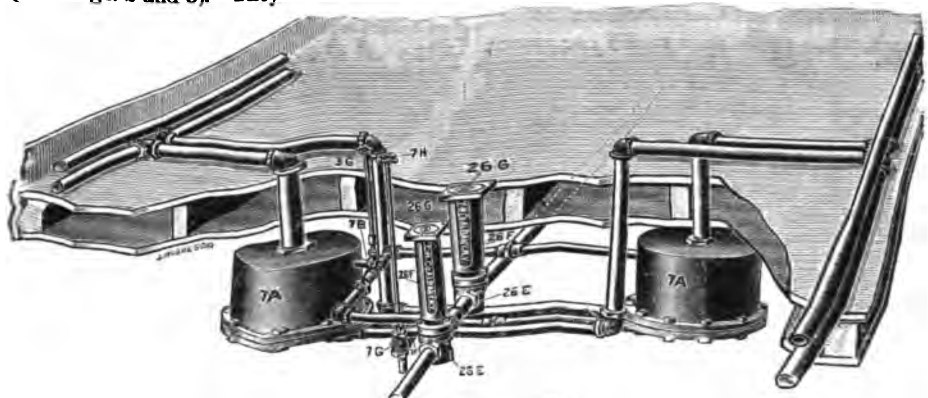


FIG. 3.—Disk drum-heater.

and as the two drums discharge into the pipes on different sides of the car, the heat in the car is evenly distributed. It is evident that the joint action of the two drums is to produce the circulation of water in the same direction through the pipes. The direction of flow is the same as when fire is used in the heater. Since the water is heated at two points, all the water is heated when it has moved through one half of a complete circuit. Steam is taken into the drum from the train-pipe, and water of condensation is removed from the drums by means of a trap or trap-valve and is discharged on the ground. A brine of salt and water is generally used as the circulating medium.

The Direct-Steam System.—In this system steam from the locomotive is turned directly into the radiating pipes of the car. Three pipes 1¼ in. in diameter are generally used on each side of the car. The three pipes are joined together at both ends of the car by a three-pipe manifold. A distributing tee is placed near the center of the car, and is connected into the two upper pipes. To this distributing tee a pipe leading from the train-pipe is connected, through which steam is supplied to the heating pipes. A tee is also placed in the lower pipe near the center of the car, and a drip-pipe is connected from this tee to a casting placed in the train-pipe in which is a bleeder-valve controlling the discharge to the ground. The pipes in the car are graded so that water will flow to the ends of the car in the two upper pipes, and then flow to the center of the car in the lower pipe, and out through the drain-pipe and the bleeder-valve in the train-pipe casting, to the ground. In the same train-pipe casting is placed the steam-valve which controls the flow of steam to both sides of the car, and the drip-pipes from both sides of the car are also controlled by the one valve above described. The two valves in the train-pipe casting are provided with extended spindles, which terminate in a floor-plate made flush with the level of the floor.

The office of the train-pipe casting above mentioned is to prevent the drip-pipes from the car from freezing by connecting them into a casting always deriving heat from the train-pipe. This feature, patented by the Consolidated Car-Heating Co., is one of great importance as, by removing the possibility of freezing the drain-pipe when the bleeder-valve is closed, it becomes practicable to nearly close the bleeder-valve and allow the pipes to fill with water of condensation when but little heat is required. In this way the fierce heat of direct steam can be toned down to meet the requirements of mild weather. In cold weather the bleeder-valve is given a larger opening, so as to allow the greater part of the radiating pipes to be filled with steam. This construction furnishes an effective means of adjusting the amount of piping filled with steam to the needs of all kinds of weather.

20 lbs. per hour. At 74° to 75° the valve entirely shuts off. It is evident that the temperature of the car equipped with this apparatus would rise to that temperature at which just sufficient steam passes the steam-valve and into the car as is necessary to maintain an even temperature, and at no time is it necessary that the steam-valve should actually shut off. It gives a throttling action upon the flow of steam. Taking into consideration the rapid rate at which this valve closes, it will be seen that, under conditions of railway service, the temperature of the car would be kept practically constant. In actual practice it has been found that the temperature of the car will be kept at 70° and within a maximum variation of 2°.

The detailed construction of this apparatus can be seen from Fig. 4. Two metallic diaphragms are employed, which are brazed together at the edges, and have metallic hubs soldered to their opposite faces at their centers. (See section on line *A*.) A small quantity of a liquid whose boiling-point is 60° F. is placed within the space between the two diaphragms. The opening to this space is then hermetically sealed. The diaphragm is then attached into a bronze framework in such a manner that the expansion of the diaphragms is communicated by means of a lever to a bell-crank, which through a rod actuates the steam-valve below. This pipe is 5 ft. long and holds the two parts of this apparatus in rigid adjustment, and also offers a protection to the rod. At a temperature below 60° F. the liquid placed between the two diaphragms remains in the form of a liquid, and the two diaphragms are collapsed. Above the boiling-point of the liquid in these diaphragms a vapor pressure is generated between the two diaphragms, forcing them apart and causing a motion in the vertical rod and its connecting mechanism against the tension of the spring shown in the framework of the regulator. The steam-valve is caused to close partially by this same movement. When the temperature rises to 70° the valve almost reaches its seat, and simply allows sufficient steam to pass to preserve an even temperature in the car. If a ventilator is open or in any way the air in the car is chilled, the effect on the diaphragms is to lower their temperature and to cause them to collapse, which is followed by a corresponding opening movement in the steam-valve. The results of tests with this apparatus have shown that the temperature of a car can be automatically held within a maximum variation of 2° with an external temperature varying from 50° above zero to 6° above zero in a run of 300 miles.

Independent Water-Heaters usually consist of a suitable jacket made of heavy sheet-iron, forming a combustion-chamber, in which is placed a coil of 1¼-in. pipe about 14 ft. long. These parts are properly mounted upon a base carrying the grate, with fire-pot and ash-pit, forming a heater of well-known construction. The coil referred to is connected up as a part of a hot-water circulating system. The heat of the combustion-chamber is conducted through the metal of the coil to the water, by which it is distributed through the circulating pipes. While this heater has rendered service for years in car-heating, it nevertheless has been found that in train-wrecks it is liable to set the cars on fire. To overcome this objection several heaters have been designed in which the fire is so inclosed that there is but little danger of live coals being scattered in case of a wreck. In an improved heater of this type the outside shell is made of 18-in. wrought-iron tubing, and is over ¼ in. thick. Within this is the cast-iron lining, which is separated from the shell by a ¼-in. thickness of asbestos fire-felt. Within this lining is placed a closely wound coil of 1¼-in. pipe 26 ft. long. Between the coil and the fire-pot is a cylindrical smoke-chamber 2 in. thick, through which the hot gases from the fire pass on all sides of the coil. The closely wound coil is filled with coal, the fire burning only at the base of the coil. A perforated malleable-iron head is bolted into the top end of the shell, through which smoke passes before reaching the stove-pipe. In the shell a sliding door covers securely the opening through which coal is fed to the interior of the heater. In case the heater should be upset in an accident, the fire can not escape at either end.

Steam-Couplers.—In continuous heating one of the most difficult problems has been to secure a connection which would couple the ends of the train-pipes together, and so make a practically continuous steam-pipe leading from the locomotive under all the cars. Rubber hose has now been generally adopted as a means for taking up the motion between cars, and to the end of such hose is attached the steam-coupler proper. This coupler must couple easily, uncouple automatically, be durable, be exactly alike in each half, and the interchangeability must not be affected by wear. Many types have been brought out, among them the McElroy, Martin, Gold, Gibbs, and Emerson, embodying some of the above-mentioned desirable features, but the tendency for two years past appears decidedly toward what is known as the Sewall pattern, many railroads in the United States and Canada having recently adopted it for steam-heated trains. The Sewall is a straight-port, abutting-face, and insulated steam-coupler. The cuts herewith show its simplicity of construction. The passage for steam is practically straight and unobstructed by strainers, springs, diaphragms, gasket-retainers, or acute angles. All its metallic parts are made of malleable or wrought iron or steel. On the coupler-head are placed a tooth and space in proper position (shown in accompanying cut, Fig. 5), to serve the double purpose of a guide for the interlocking devices when being coupled, and also to retain the coupler-heads in proper

FIG. 5.—Sewall's steam-coupler.

...and attractive design of buck-board, having three seats and a rumble (adapted for ...gers) meets with a steady demand. The natural-wood finish is again the favorite, ...corduroy trimming and black iron-work. The construction of the body is simple. ...m boards consist of three pieces of 1⅛-in. ash, with three cross-pieces 4 × 1¼ in. in ... tapered to ½ in. at the ends. At the rear end of the body two pieces are bolted to ...n boards, extending back about 24 in. to take the foot-board for the rumble. The ...are of locust. There are front and rear springs, and a cross-spring both at front and the vehicle has two perches. Width of body, about 30 in.; wheels, 46 in. front ... rear in the wood; center to center of axles, 91 in.; track, 4 ft. 8 in.; diameter of ...wheel, 14 in. The above are the principal measurements only; builders of buck-... be able to readily supply the rest.

...r novelty in buck-board wagons was recently built in Newark, N. J. The front ...ged, and on lifting it a child's seat may be drawn out; this has a hinged iron sup-... then falls into place. The rear seat is hung on jump-seat or loop-irons, so that it ...ced in any part of the back of the body. The rumble is made of bent stock, as a nice set-off to the natural-wood body finish, the gearing is striped with carmine.

...pindle-Wagons.—The principal change in the designs of spindle-wagons is the ...ved toe-bracket, which has a graceful and pleasing effect. The suspension is on ...er springs, with side-bar and bolsters, which allow the body to be hung compara-... The body-sills are of hard body ash, bent at the toe to the shape of the pattern. ...er-plate screwed to the inside of the sills gives extra strength. ...re now often made with four elliptic springs instead of suspending them on side-... elliptic springs with high wheels. A wheel-house can be used to great advantage ...n with this new arrangement. In one particular form the sides of the body are there is no door between the seats, but the front seat is made to turn over, which ...cess to the rear of the body. Surreys also have canopied tops fitted to them oc-...

...g Vehicles are constructed in a variety of styles, and their bodies often take the ...ods carried, notably the shoe and the hat.

...mbulances.—One of the latest styles of ambulance-wagons has the body sus-... t at the rear it is only 17 in. from the ground, which affords easy access to the ...he rear, this being the desideratum. There is a wheel-house in front to allow ...g. The upper part of the body is fitted with imitation shutters, which can be ...ered to admit of ventilation; these shutters are secured from rattling by light ...rips. The two doors at the rear are hung on concealed hinges, and open out entire width of back. Two beds can be used in this wagon, one hung above ... front is suspended on an open futchel-gear, with the regular elliptic springs. ...axle cranked down 17 in., and is suspended on a half-double sweep-spring. ...of the body, up to where the spring is attached, is narrowed 3 in. on each side, ...outside at the top and 42 in. wide at the bottom, with a 5 ft. 2 in. track all ...ront wheels are 36 in. diameter and the rear 54 in.; number of spokes, 16; ...enter to center of axles, 78 in.; diameter of fifth wheel, 22 in.; weight of ...about 1,100 lbs.

...in city ambulances, Fig. 3, constructed after the plans of Dr. Nachtel, of ...their way. Its smooth and varnished sides permit the vehicle to be kept perfectly clean. A litter of light wicker-work, of proper and convenient form, gliding along two grooves, receives the patient, who, owing to the elasticity of this material, is enabled to rest comfortably, and without experiencing the usual though unnecessary jolting heretofore incidental to being rapidly conveyed over roughly paved streets. A little shelf contains all that is requisite for the dressing of wounds *en route*. The ambulance is lighted by two large windows on each side. The entrance at the rear is closed by means of full-width folding-doors, thus preventing the cold air and drafts from reaching the occupants, which is at present one of the objectionable features of the American ambulance.

...3.—French ambulance.

Gears.—A new gear, known as the "Equivalent" (Bartholomew's ...ently put upon the market. It is intended specially for "cut-under" ...reys, hacks, road-wagons, and light-delivery wagons, which are often re-... This gear takes the place of the platform ordinarily used for carriages,

e driver, so that he can, quickly and easily, while retaining his seat and and reins in hand, glide the seat forward or backward to suit the ine-l, and preserve the perfect balance of the carriage. Directly the handle is ceases to turn it, the seat remains fixed and immovable. The arrange-ied to any existing two-wheeled cart; a sliding foot-rest usually accom-

on-springs, when applied to a side-bar wagon, are capable of self-adjust-t themselves to any variation of load, and rendering the riding invariably nce to the number of persons occupying the vehicle. The inner ends of e fastened to the middle of the spring-bar with the same bolts as the e outer ends of the cushions are bolted to the side-sills. These cushions a slight degree—just enough to break the force of a sudden shock. They springs, causing the openings between the cushions and springs to close, unt of pressure, thereby virtually shortening the springs, and thus regu-o agree with the load carried.

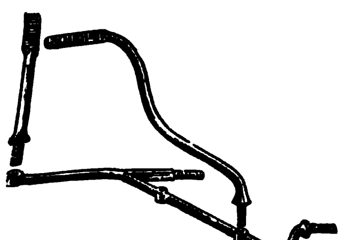
tent Tire.—Fig. 7 is practically a universal felloe-clamp. It has two inclose the felloe, which effectually prevent it from coming off without

Fig. 8.—Thill-coupling.

s, bolts, or other fastenings. To protect the felloe from damage by , etc., the tire has lateral rims or flanges, and the first-named flanges ther and prevent it from splitting.

of flanges also strengthens both tire and felloe, and prevents bend-tually preventing the wheel from getting out of shape.

vel form, made by the Instant Thill Coupling Co., is shown in e axle have forwardly projecting lugs coupled by a strong steel-bolt, which is embraced, in the space between the lugs, by a pair of semicircular jaws, one of the latter being rigidly attached to the shaft-end by bolts and clips, and the other pivotally connected with the first, leaving a thumb-lever projecting beyond the pivot so as to be easily pressed upon to open the jaws in shifting thills. There is a spring under it to regulate its play. No wrench is required, and absolute safety and the maximum convenience are claimed for the appliance.



iage-irons.

d uplicated by drop-forging, and these parts on all standard hangeable throughout the respective styles and sizes. The

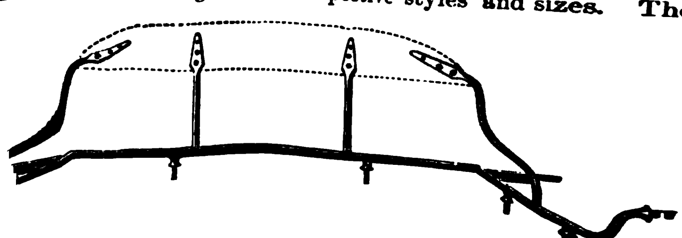


Fig. 10.—Carriage-irons.

icandescent lamps with reflectors are placed in the lanterns are supplied from a storage-battery carried on the floor of

le in this direction alone. But it is in the sub-
ficult setting of all of them to match, that the
ystem lies; besides which there is an additional
ng two sets of knives side by side at 5,000 turns
heir cuts meet, yet without the cutters themselves
le fly-cutter undesirable, particularly where work
ed out at a low price.

her class of machine originally devised to produce
at the end of a spindle that is set square with the
cut is fed endwise, causing the cutter to bore to
e. In this class of machine there are required both
uble-fly cutter, and both they and the belt must be
sts. There being but limited space between the two
om for only one knife, and, as this can not be set at
actically scrapes its way through the stock—a slow
arpening of the cutting-tool. The Pryibil machine
and the scraping tools, but the former are used only
re there is a space between two separate and discon-
l the other, but not touching it. Fly-cutters can not
y other class of work. They have been made to do
o their collars at an angle of 45°, causing them to cut
ide of the work toward the center. As the knives are
aced and right and left, the two of a pair can be placed

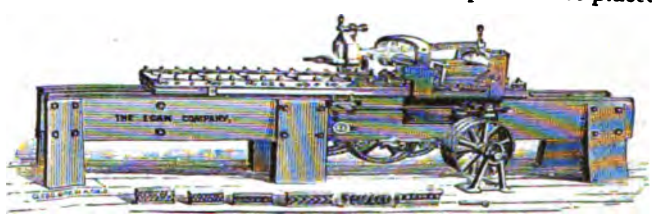


FIG. 2.—Egan carved-molding machine.

t are large in the middle and small at both ends—to be
den forms. This machine is particularly well adapted to
rish" pattern, consisting of long, thin spirals interwoven
like wire-netting. Such work is ordinarily considered very difficult to make, by reason of the trouble in getting the thin sticks to stand up against the cut. In the subject of this illustration there is a steady rest directly opposite the cutter, holding a wooden block, through which a hole is bored, fitting the stick to be cut spiral. The cutter works its own way through the block to the work, and, as the cutter and the block maintain their relative position while the work feeds along, the latter can not spring or break. The spindle-frame of this machine is counterbalanced so as to swing easily from right to left, and is fed to the work by a quick lever-motion. Changes of twist are produced by turning two wheels on a screw, according to a table attached to the machine; the change from right to left is effected by placing the gears on one or the other side of a rack.

g-machine.

The Egan Carved-Molding Machine.—A machine for making carved moldings, and built by the Egan Co., is shown in Fig. 2, its function being to cut moldings without a pattern and leave sharp corners. There is a frame of heavy timbers, much like that of an ordinary Daniell's wood-planer, with suitable heavy iron slides at the top for the bed to travel over. The lower part of the bed has spur and rack gearing, giving an auto-
th to the carriage or bed which bears the work. The travel of
at long or short moldings may be made at will. The head or tool-
ntal studs at the right of the housing of the machine, and is made
ns borne by the front end of its saddle come into contact with up-
ne sides of the traveling-bed. The shape of the knives, which are
the molding, of course modified by the action of the cams and studs
out of cut as the material is fed along under the knives, and by the

position of the knives with regard to the tool-post. The bed traveling back and forth, and the tool-post and its knives working up and down as the cams pass over the studs on the carriage, produce the proper combination of movements to make carved moldings.

A Geometrical Carving and Corner-Block Machine, Fig. 3, patented by S. Y. Kittle, is used in making interior wood-decorations for ceilings, such as corner-pieces, center-pieces, borders, etc. There is a frame which has a square table or box with a flaring base, and a continuation having a gap somewhat in the manner of a band-saw or drill-press frame; this carries a vertical router-spindle, the pulley of which has one bearing above and one below, the belt passing over two idler-pulleys at the back of the frame and down over the main pulley, which is at the bottom of the machine, at the back, the shaft running fore and aft, and hence at right angles to the router pulley-shaft and the idler-shaft. The table has vertical motion by a rack and pinion, and horizontal adjustment, as well as tipping motion for certain classes of work. There are adjustable stops to regulate the depth of cut; and the table has an index for dividing and regulating its circular movement. There are suitable clamps and jaws for centering and holding down the blocks, and the whole table is counterbalanced, so as to move more readily up and down by a hand-lever. The router-shaft pulley is covered by a casing which protects the operator, and keeps oil from being slung over him and the work. By this machine, work of the class done in metal by a rose-engine or geometrical lathe may be effected; and by an attachment the operator can cut designs on material of any length, as in the case of long boards on mantel-pieces. Another attachment is for routing or duplicating operations in line for fancy moldings, consisting of a table with rack and pinion-feed, that may be fed along by a hand-wheel, or by a lever and ratchet, as desired.

CENTERING-MACHINE. A new double-spindle centering-machine, made by the D. E. Whiton Machine Co., New London, Conn., is shown in Fig 1. Two spindles are provided, one of which carries a drill, and the other a reamer or countersink. They are driven at different speeds, by a single belt, over a pulley whose center is in line with the center of the lateral movement of the head. Both spindles are balanced by springs as in sensitive drills, and are successively advanced to their respective cuts by a feeding-lever.

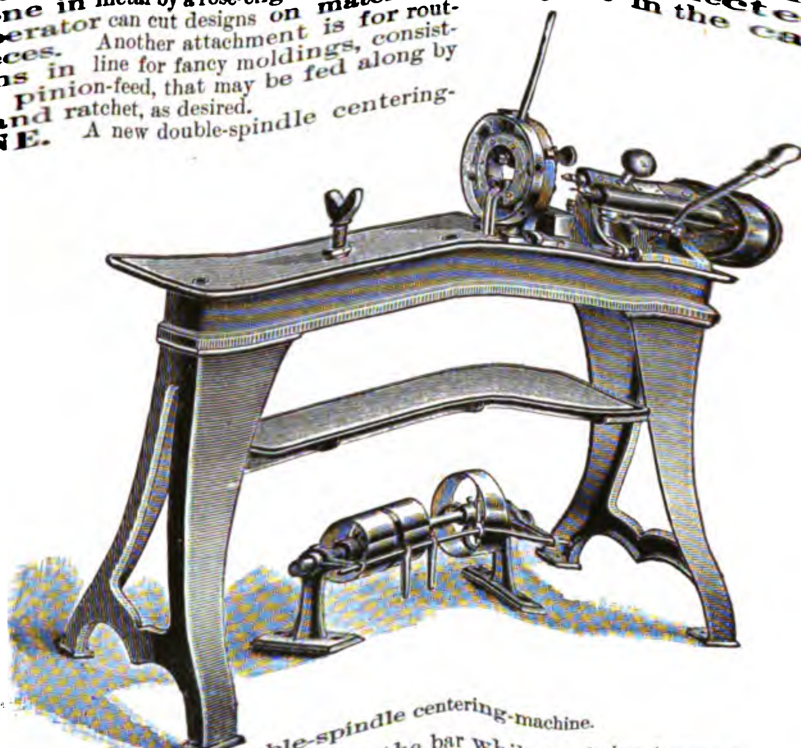


Fig. 1.—Double-spindle centering-machine.

The machine is so arranged that neither spindle can be advanced by the feeding-lever except at the central point. The moment this advance is begun no lateral movement of the head is possible, nor is lateral movement again possible until the return of the spindle to its normal withdrawn position. A support is provided for the front end of the bar while it is being inserted in the chuck, in addition to the V-shaped rest for the rear end. The chuck is thereby made self-centering.

Centrifugal Extractor: see Creamers.

Centrifugal Pumps: see Pumps, Rotary.

Centrifugal Reels: see Milling Machinery, Grain.

Chain Machine: see Rope-Making Machines.

Channeling: see Quarrying Machines.

Check Rower: see Seeders and Drills.

Check Valves: see Valves.

Chemical Fire-Engine: see Engines, Fire, Chemical.

Chlorinating Machine: see Mills, Gold.

Chrome Steel: see Alloys.

Clay Filter: see Filters.

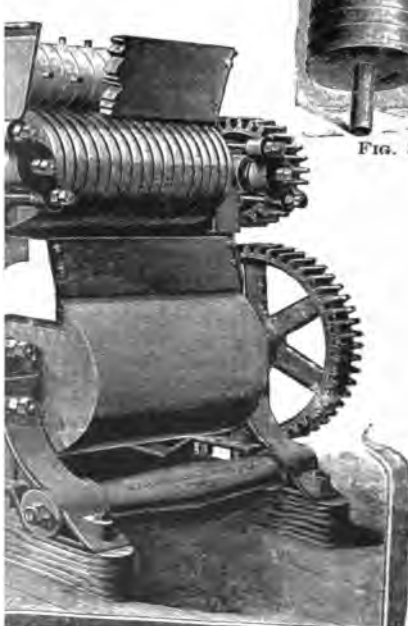
CLAY-WORKING MACHINERY. Apparatus for the treatment and handling of clay prior to its manufacture into bricks, tiles, etc. When clay is thoroughly and evenly tempered, it is then in best condition to make a good brick. Hence, since clay in its natural state is found in such a variety of conditions, the question of properly preparing it for the machine, with the least expense and the best results, becomes a matter of importance. It is seldom, if ever, the case that a bed of clay is found with moisture so evenly distributed in it that it is just in the right condition to work the season through. A very common as well as successful plan is to soak the clay in pits. Two pits are used, one being filled and soaked while the

s either too dry or too wet does not work satis-
s if the entire mass was uniform in temper when
come by carefully soaking in clay-pits, or by
equivalent preparation by pug-mills and crush-
ers. When pits are used, the clay should be leveled off in the pits, and the lumps broken up after every few loads. A sufficient amount of water should then be thrown upon it, and this operation repeated until the pit is full. By this means the clay will neither be too soft at the bottom or at the top, but evenly tempered throughout. A little experience and observation will suffice to obtain good results in tempering the clay. To facilitate the convenience of soaking the clay-pit, a tank should be erected high enough so that the water can be thrown from it by the use of a hose, and in this way one person can easily supply the necessary amount of water without any hindrance to the other part of the work. In a very few cases the clay comes from the bank in the right condition to go at once into the machine. In this case it is best to have a platform arranged over the machine, on a level with the top, so that the clay can be dumped on this platform, and with the least possible labor thrown into the machine. In dry weather, when the clay-bank has a tendency to dry up badly, it is a very good practice to arrange to partially soak the clay in the bank by means of throwing water over the bank, or if possible irrigate it by digging trenches over the bank and allowing the water to flow through them.

:hines for crushing and granulating clay embody
ed as automatically to separate out the stones

l by Messrs. H. Brewer
'ig. 1. This apparatus
diameters respectively

FIG. 3.—Detail.



clay-crusher.

of 14 in. and 17 in. at the ends. The stones are separated from the clay, and are discharged at one end of the rolls. The rolls are made of chilled castings, and are run at unequal speeds, the effect being to disintegrate the clay more thoroughly. Such of the clay as does not pass between the rolls moves toward the transverse crushing-roll, which is placed near their larger ends. The unequal revolutions of the two crushing-rolls, taken in connection with the fact that the periphery of each roll has a varying speed throughout its entire length—owing to their conical form—has proved that all the clay, except the very large lumps, will be drawn between the crushing-rolls before it reaches the transverse roll. The periphery of the transverse roll is of irregular form, and is also provided with teeth, or spurs, both of which assist in breaking up the clay. The transverse roll revolves with its upper surface turning toward the moving clay, and any lumps or clods of clay with which it may come in contact, whether moist or dry, are readily broken up and forced between the two crushing-rolls.

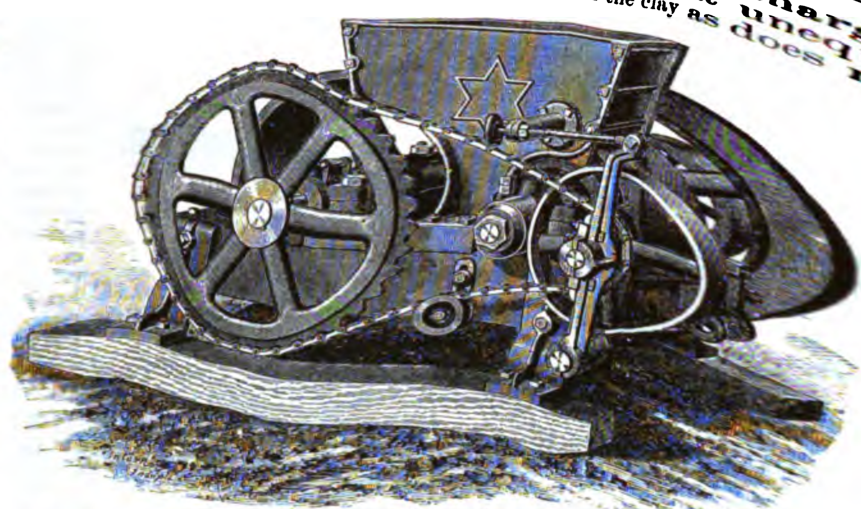


FIG. 4.—Clay disintegrator.

The Penfield Clay-Crusher, manufactured by Messrs. J. W. Penfield & Son, of Willoughby, Ohio, is represented in Fig. 2. The peculiar construction of the crushing-rollers in this machine will be noted in Fig. 3. On each there is a broad spiral corrugation, right and left hand respectively, which extends the entire length of the roll. The projection on one roll fits into the corresponding depression on the other, so that the rolls can always be set closely together, and any wear be thus taken up. When running at a moderate speed, the clay passes freely through the rollers and is crushed, while all stones too large to be at once crushed are quickly passed to one end and out of the crusher through an automatic gate. The rollers run at different speeds; usually one about twice as fast as the other. The mode of applying this so-called differential principle to corrugated rolls is exceedingly ingenious; the necessity

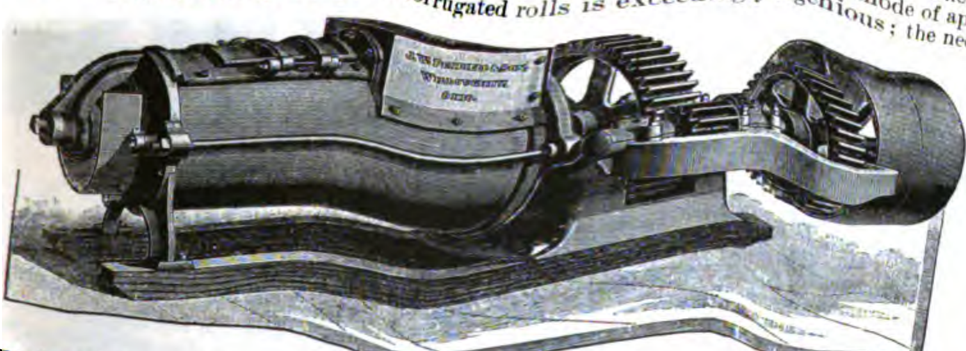


FIG. 5.—Pug-mill.

of exact matching of the corrugations, and, at the same time, of driving the rolls at different speeds, resulting in a problem not easy to solve. The high-speed roll is made with a single thread or corrugation running at 1½-in. pitch; the slow-roll has a double-thread or corrugation running at 3-in. pitch, twice as great; hence, the corrugations on the former will advance the same in two turns as the latter in one. In the machine represented in Fig. 2 the upper rollers are corrugated, and are 17 in. in diameter and 36 in. in length. The lower rollers are smooth, 24 in. in diameter and 36 in. long, and are geared to run at differential motion. Heavy car-springs are arranged between the boxes of the adjustable roller. The height of this machine is 5 ft. 6 in., and it crushes clay sufficient for from 40,000 to 60,000 bricks per day.

The Ports Clay Disintegrator, illustrated in Fig. 4, is especially adapted for tough, stony clay, which it pulverizes by removing successive portions from a mass thrown into the hopper; the action being similar to that of a file or grater. The mechanism consists of a cutting cylinder, revolving from 500 to 800 revolutions per minute, in combination with a cylinder of larger diameter, revolving at from 20 to 50 revolutions per minute. The clay is carried through and ground entirely by the action of the high-speed cylinder, the low-speed cylinder

acting simply as a feed-roller. By the differential speed, and by the cutting action of projecting bars on the roll, the clay is finely divided.

Pug-Mills often receive clay in a crude state just as it comes from the bank, and reduce and pug it, to bring it to tempered condition. They are also employed to mix two or more kinds of clay together, or to combine it with sand, sawdust, grout, or other material. Fig. 5 represents a Penfield pug-mill, capable of pugging the clay for from 40,000 to 50,000 bricks per day. The tempering-tub is made of heavy boiler-plate, is 5 ft. long, 29 in. in diameter at the large end, tapering down to 25 in. at the small end, and is provided with a large hinged door. The main shaft is of forged steel, 4¼ in. in diameter where the gears are attached, and hammered square where the knives fit on. The pugging-shaft is provided with a wrought washer and brass wear-plates at the back end, receiving the end-thrust of shaft. The journals are all long, and shafting proportionately heavy.

FIG. 6.—Clay tempering-wheel.

Tempering-Wheels are employed for mixing and tempering the clay in the pit. Raymond's wheel, illustrated in Fig. 6, has 16 spokes and a double tire. It is operated in the pit by either steam or horse power. The clay is worked between the spokes as well as between the tires. By an automatic arrangement of the rod and pinion, the wheel is drawn back and forth on the shaft, changing its position with each revolution, and reversing itself both at the outer and inner edge of the pit.

Cleaning Machine: see Flax Machines.

Clocks: see Watches and Clocks.

CLUTCHES AND COUPLINGS. *The Hill Friction-Clutch Pulley* is shown in Fig. 1. The pulley is cast with a rim projecting from the arms, inside of and concentric with the ordinary rim, which rim is gripped on both sides by wooden blocks. These are moved by a combination of toggles, whose action is shown in the sectional view.

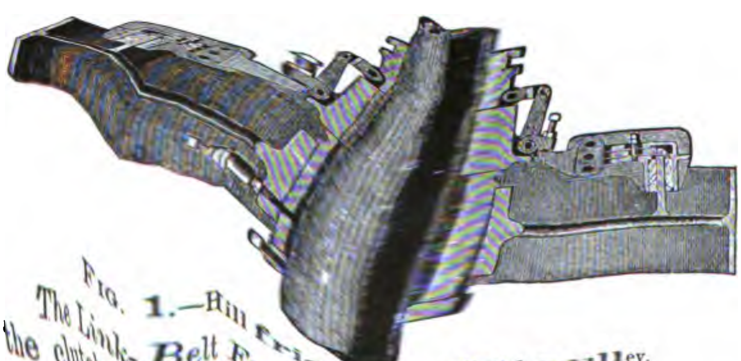


FIG. 1.—Hill friction-clutch pulley.

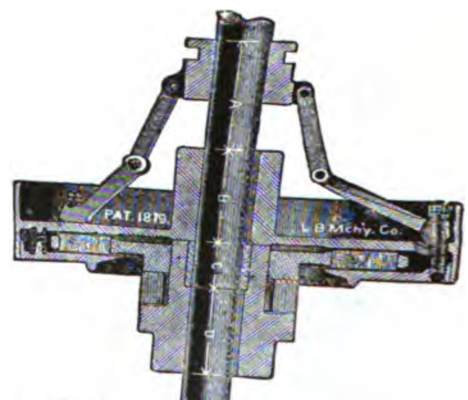


FIG. 2.—Link Belt Eng. Co.'s disk friction-clutch.

The Link-Belt Engineering Co.'s *Disk Friction-Clutch* is shown in Fig. 2; figure showing the clutch in engagement, and figure disengaged. It consists of a plate-center pulley, containing beneath its rim on one side the toggle-lever mechanism, and on the other the clamping-plate, embracing a disk which is provided with projecting hard-wood plugs. This disk is loosely interlocked with square jaws on the hub of the pulley, wheel, or coupling.

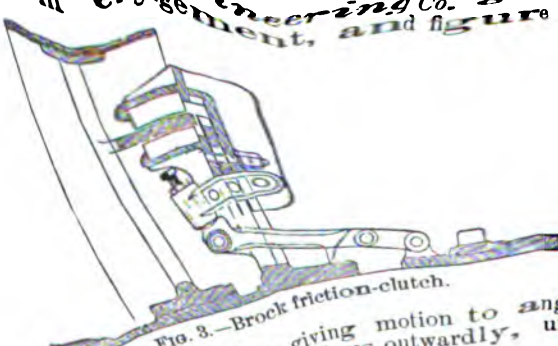


FIG. 3.—Brock friction-clutch.

The Brock Friction-Clutch, a portion of which is shown in the sectional view (Fig. 3), has a rim which is grasped on the inner and outer sides by the clutch members, which are shod with seasoned maple. The radial motion of the jaws or clutch members is produced by the sliding piece (seen to the right of the pulley) being pushed toward the clutch or pulley, giving motion to angled levers, which force the upper or outer jaws inwardly and the inner jaws outwardly, until they grip firmly both sides of the rim. Moving

the sliding piece away from the clutch, in the position shown in cut, disengages the jaws or frictional surfaces.

The Weston Safety Ratchet, as applied to crabs, winches, and similar hoisting apparatus, is shown in Fig 4. The principle is based upon the combined use of a friction-clutch with a ratchet wheel and pawl in such a manner that the action of the weight tightens the clutch and prevents all possibility of accidental release. The reverse motion of the handle releases the clutch and permits the load to follow, but any variation in the speed of the crank-motion is followed by a corresponding variation in the barrel-movement, and when the motion of the crank is stopped, either intentionally or accidentally, the barrel also stops. Referring to the cut, *D* is a section of a spur-pinion suitable to be used in connection with any light train of gearing. At *C* is a ratchet-wheel with which a pawl engages, and which can thus only revolve freely in one direction. Between *D* and the ratchet-wheel *C* are several friction disks, the alternate ones being connected with pinion and ratchet-wheel, and giving enough friction surface to hold the two parts firmly together as a unit when they are forced into close frictional contact. Both pinion and ratchet-wheel are loose upon the shaft *A*, and are placed between two collars. One collar, *B*, is pinned fast to the shaft, and is a plain collar. The other collar, *E*, has a helix formed upon its side, and there is a corresponding helix upon the hub of the pinion upon that side. This collar *E* is also pinned fast to the shaft, so that there is but slight play between the parts, just enough to permit the engagement or release of the friction-disks. When the shaft *A*, carrying with it the collar *E*, is revolved, the top moving toward the observer, the helix on the collar acts as a circular wedge upon the helix on the pinion-hub, and forces the friction-disks tightly together, and also tightens the whole series upon the shaft; and any motion given to the shaft *A* is transmitted through the pinion *D*, just as if it were keyed fast. The same action takes place when the load attempts to rotate the pinion backward. When it is desired to lower the load, the shaft *A* is turned backward. The ratchet-wheel can not revolve in that direction, as it is held by the pawl, and, as the pinion is held by the friction-disks, the shaft alone is turned, carrying with it the collar *E*. This motion releases the wedge action of the helix, and reduces the pressure upon the disks, and hence the load can now pull the pinion backward, the alternate disks slipping upon each other. Any tendency for the load to turn the pinion faster than the shaft and collar *E* at once creates an increase in the friction between the disks, and so the pinion can not run down any faster than the motion of the crank and shaft, and, if the crank is for any reason let go, the friction-disks will at once tighten and hold the load.

Fig. 4.—Weston safety ratchet.

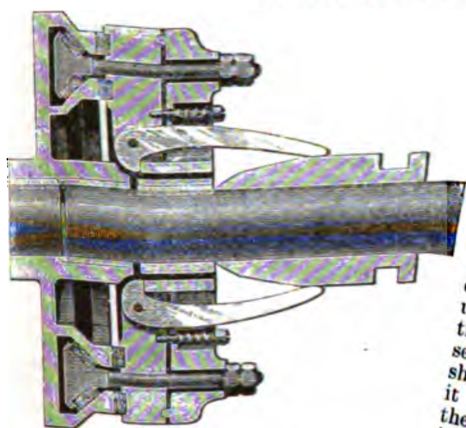


Fig. 5.—Frisbie's cut-off coupling.

Frisbie's Friction-Clutch (Fig. 5) is used in connection with a hoisting-drum, such as is used in pile-drivers and like hoisting machinery. The sectional view shows its use as a cut-off coupling. The rim of the clutch, as shown, contains a groove with internal beveled surfaces, each of which is pressed by wooden blocks which are drawn outward

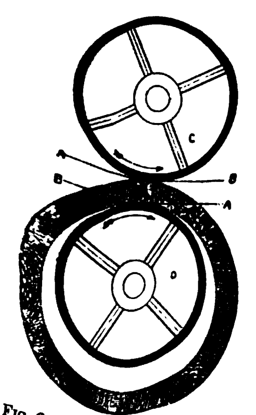


Fig. 6.—Frictional belt-gearing.

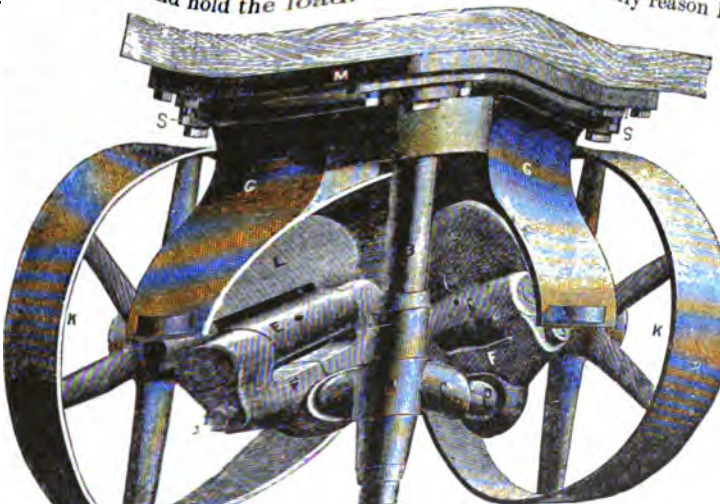


Fig. 7.—Almond's right-angled coupling.

long arm of which rides upon a cone, which is moved

:em of transmitting power by belts and pulleys, made
iton, is shown in Fig. 6. The power is transmitted
it is nearly in contact, by a ring or belt of leather,
t surfaces of the pulleys, and transmits the power by
e principle of the system. The diametrical line *B B*
hen the pulleys are idle, but little pressure remaining
ows the points of contact of the belt when the pulleys
ing pulley *C* is transmitted to the outer face of the
is of the driven pulley.

Fig. 7 shows a form of shaft-coupling made by T. R.
ing motion between two shafts at right angles to each
he post *B*, carries two studs *C* at right angles to each
ball-and-cup joint to the forked piece *F*, which oscillates on pins formed on the piece *E*, which rotates with the pulley *K*. Motion being given to either pulley *K*, it causes the stud *C* on the same side to be carried upward and downward, and to be oscillated back and forth as the sleeve *A* moves on the post *B*. On the other side these motions are all reproduced, causing the other pulley *K* to rotate. The coupling is inclosed in a metal case, which holds a supply of oil sufficient to last from one to two years.

oint.

The States Machine Co.'s Angle-Joint is shown in Fig. 8. One joint will operate within an angle of 110°, and a pair used jointly will operate within 70°. The sectional view clearly shows the construction. The end of each of the coupled shafts is
ılar projection T-shaped in section. These projections
angles in a steel ball. The ball is made in pieces for
gether. The coupling is especially adapted for feeding
rer has to be transmitted at a varying angle.

ers and the machinery used in them for the preparation
een ably described by Mr. Eckley B. Coxe, in the *Trans-
Mining Engineers*, xix, 898, of which this article is
as it comes from the mines is not marketable. The
of bituminous coal, be sold. Anthracite, being very
tile combustible matter, burns only at the surface, and
ave the lumps as nearly of a uniform size as possible.
of surface will remain exposed to the action of the air
or allowing enough air to pass to cool the coal below
the pieces of coal of the size of a chestnut and smaller
an egg, they fill the air-passages and prevent a free
therefore, that one of the most important points in
, and also to make as large a number of different sizes
; expense. It is also essential to remove all the dust,
nd depreciates the value of coal in the market.

unts of slate, "slate-coal" and "bony coal" generally
only used to designate lumps composed partly of coal
coal occurs in such large masses that, by rebreaking,
can be obtained economically; and "bony coal" to
slate are so interstratified that they can not be sepa-
aration; also coal in which the impurities are present
r greatly diminish its market value. In other words,
ng and preparation, a certain amount of pure coal can
not be economically rendered more pure by mechani-
l for certain purposes in its crude condition.

ities as completely as possible. Of course, when the
d be eliminated without further breaking. But the
pieces to separate the slaty portion from the coal. It
ger lumps which come from the mines, and machinery
into such sizes as the market requires.

ıld be divided into its various sizes, and the free slate
y breaking is done. This can be done either by hand-
irst case the coal is passed along chutes, on the sides
pick out the slate, and in some cases the bony and
s into the pockets. The mechanical slating of the
physical characteristics of the coal and slate: the
difference of the forms in which they break; and the

difference of their angle of friction, or, in other words, the difference in the angle of a chute lined with stone or iron, down which the coal or slate will slide without any increase of velocity. As a rule, slate will not slide down a chute which will carry coal.

Machinery for Sizing Coal.—This may be divided into two classes: fixed or movable bars, and fixed or movable screens. In the first, the openings through which the coal falls are much longer than they are wide, while in the second the ratio of the length to the width of openings does not generally vary much from unity. In special cases the first class may be used to take out dust or fine coal; otherwise, they are seldom employed, except for large coal, unless when exact sizing is not important. The reason is, that long, flat pieces fall out with the cubical pieces of much smaller dimensions, rendering the coal thus sized unsightly, inconvenient to handle in the furnace, etc. There are three types of the first class now in common use: 1. The adjustable bars, supported at both ends. 2. The finger-bars, supported at one end. 3. The oscillating bars.

The Adjustable Bars are, as the name implies, a series of bars, whose position can be adjusted, over which the coal to be sized is made to slide longitudinally. The ends of the bars are made V-shaped, and they fit into similar grooves on the transverse pieces by which they are supported, so that the bars can be placed at required distances from each other varying with the width of the bases of the triangles, which is usually about 4 in. The bars are generally made 4 ft. long, but, of course, can be made of any size.

The Finger-Bars are an improvement upon the ordinary bars, and have been recently introduced. In using the continuous bars, part of the dirt and fine coal is often carried over the bar, and is delivered in the chute at the lower end, instead of falling through; and as the spaces between the bars are parallel and closed at the lower end, long pieces often wedge and catch, particularly at the bottom, thus necessitating a frequent cleaning. Of the finger-bars, the lower end is entirely free, and the bars are narrower there than at the upper end, and any lump that may wedge is likely to be loosened by the first lump which strikes it. Upon the vertical portion at the upper end of the bars are two half-holes, by which they are bolted to the beam or bar-bearings.

The Movable or Oscillating Bars consists essentially of a series of double bars, placed sufficiently far apart to allow coal of the required size to pass between the bars of each pair. The lower ends of the bars have semicircular bearings, which fit over a horizontal shaft, while the upper ends are supported upon two round steel rollers. The bars are oscillated back and forth by eccentrics on the main driving-shaft, which are so connected with the bars that the motion of the latter is approximately horizontal. The throw given them is about 3 in. On the main or driving shaft there are two eccentrics, placed 180° apart. The bars are flat on top, the extreme lower end being rounded off to allow the coal to roll off easily; then for a certain distance they are horizontal, rising finally in a curve, the center of which is upward, to the point where the coal arrives upon the bars. The upper ends of the bars, which are carried by the rollers, extend under the chute whence the coal is fed.

Fixed Screens may be either fixed or movable. The former consists simply of an inclined plane, formed either of woven wire screens or punched or cast plates, with round, square, elliptical, etc., holes. The coal in this case is allowed to slide or roll by gravity, not too rapidly, down this plane. The larger pieces pass over, and the smaller fall through. By placing several screens with openings of decreasing size underneath one another, or a series with openings of increasing size, in the same chute below one another, any desired number of sizes can be made. The objection to these is that their capacity is limited, the sizing is imperfect, and the screens clog more or less.

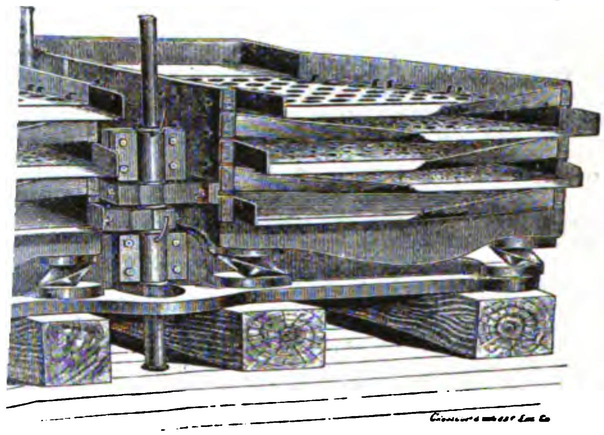
Movable Screens.—The movable screens are among the most important parts of a breaker. They are of two types. In the first type the screening surface forms a cylinder and revolves about its axis. In the other type the screening surface is approximately horizontal, and the motion and action are very similar to that of an ordinary hand-sieve. In many cases the screen is moved backward and forward in an approximately horizontal plane. This motion, combined with the inclination of the sieve, causes the coal which is fed on the higher part of the screen to travel gradually across it, allowing the smaller particles to fall through. In other cases the approximately horizontal screen receives a gyratory motion, like the motion a molder gives to his sieve when screening his sand. Its great advantage is that the whole surface of the screen is constantly in action, while in the revolving screen of say 5 ft. in diameter only about 8 in. of the 16 ft. circumference is at any one time in action, unless the screen is overcrowded, and the revolving of the screen acts like an elevator and tends to throw the coal back into the screen.

The problem of constructing a gyrating screen, when the screen is to be large and must make a great number of sizes, is to support it in such a manner that it will gyrate easily and safely, and at the same time be self-contained, so that the centrifugal force will be counterbalanced and will not shake the building. The method consists essentially in supporting one horizontal plane upon another by means of three or more double cones, while the motion of gyration is given to the upper plate by a crank upon a shaft passing through and journaled in the lower plates. The cones roll freely in a prescribed path on the lower plate, while the upper plate moves upon the other end of the double cone, its relative motion to that of the cone being the same as that of the bottom plate. The result is that every point on the upper plate describes a circle of the same diameter (in coal-screens generally about 4 in.), but no two circles have the same center.

The cones may be guided in various ways. By one method the upper and lower plates are made with an annular, truncated, V-shaped track, which fits into a corresponding groove in

by an annular grove in the running-plate and a cone at the outer edge. When, however, the lency in the double cone to fly from the center; :l is sometimes made conical, so that the weight ɜ toward the center, thus counteracting the cen- e the circumferential surface of the enlargement : the outer surface of the groove in the running- ɔ resist any tendency of the centrifugal force to

the guiding is done by a ball-and-socket joint at ing-plates and cones in this type are made in the ıe precautions are taken in the lower right cut as of the centrifugal force.
he screen-box is commonly made about 4 ft. wide umber of shelves varies from two to six, depend-



ɔuble gyrating screen.

The smaller the size of coal, the closer to each other ɜ made from 1 to 2 ft. deep. The double gyrating single screens, driven by two parallel vertical shafts, close together, and placed 180° apart. In the latest n a shaft connected with the outside end of each box eccentrics of the driving-shafts are lessened, and the ıt a higher rate of speed. It has been found that the t from 140 to 145 gyrations per minute. The screens ıen the holes are large, but punched steel is generally sionally used for small sizes.
ꞅ breaking up the coal two methods are used. When ! slate attached to them are of such a character as to re broken by hand, the men using picks made for that ırge pieces of pure coal or pure slate can often be ob- ırger portion of the breaking is done by rolls.
eaking coal are of two kinds, those with pointed teeth ·rugated rolls (Fig. 2), in which the teeth are continu- ɜ other. In the latter there are no points, and the ightly rounded, the part doing the work being cast in ter endurance.
a roll as ordinarily constructed—i. e., with pointed of the teeth inserts itself into a lump of coal which olls, and breaks it very much as the stroke of a pick ·nes of fracture radiate approximately from the point ; the lump of coal. If two pieces of round iron are another, and at such a distance apart that a piece of rted by them, and if a third piece of round iron, ı and in a direction parallel to and above the other wn upon the coal, the piece of coal will break near of wood subjected to a load in the middle too great sult of this action is generally to break the lump into : same size, which is the result desired.
experiment has shown that successive reductions give uce the minimum amount of fines—and most breakers is not necessary, consequently, to change the distance

between the centers of the shafts of the rolls after the proper distance for most economical breaking has once been determined, and the rolls are made with fixed bearings. Where it is desired to crush coal to various sizes with the same set of rolls, those with adjustable bearings are used.

Taper rolls, the construction of which is shown in Fig. 3, are sometimes used where a small quantity of a number of different sizes is to be broken up at once. At the upper or larger end the rolls will take steamboat; a little farther from the end they will take egg; and a little farther they will take broken; a little farther stove. When the coal to be broken up is of different sizes, and the quantity not large, these rolls may be economical, but the tendency of practice at the best breakers is to increase the number of rolls, having a different roll for each size to be broken.

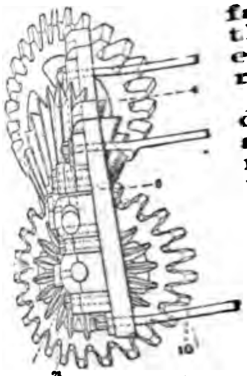


FIG. 3.—Taper rolls.

Jigs.—The jigs used in washing coal are modifications of the ordinary Hartz jig used in ore-dressing, differing only in size, capacity, and minor details of construction. The principle of coal-washing, moreover, is identical with that of ore-dressing, except that in the latter heavy mineral is separated from lighter gangue, which is thrown away, while in the former light coal is to be separated from heavier slate or pyrites. The coal-jigs in general use are invariably of the side-piston type, and consist of a single compartment. In the jigs used at the Drifton breaker (Fig. 4) the sieves are 5 ft. long and 3 ft. wide, and the pistons of the same size. The bottom of the jig is semi-circular. The coal to be washed is fed on to the jig at the side of the sieve next the piston, over an adjustable plate (6), the lower end of which is placed as near the sieve as is consistent with a free discharge of the coal. The coal passes out under this, spreading over the sieve, its constituents arranging themselves according to their specific gravities—the slate and pyrites at the bottom and the pure coal at the top. At the outside of the sieve the pure coal is skimmed off from the top by a series of flat strips of iron carried on two rows of link-belt chains, running over a wheel (34), or by some similar device. The coal is thus dragged up an inclined plane and discharged, the water carried with it draining back to the jig. The slate passes out through an opening in the side of the jig just above the sieve, which is regulated by an adjustable slide, into a flat cast-iron hopper (9). The bottom of this hopper is closed by a gate, which allows neither slate nor water to escape. This gate is opened at proper intervals, the upper opening from the sieve to the hopper being closed at the same time, and the accumulated slate discharged from the hopper into a trough, whence it is removed by a suitable conveyor after having been inspected.

For jigging fine coal similar jigs are used, but the sieves are bedded with feldspar or like material of approximately the same specific gravity. In jigs of this class the slate discharges through a goose-neck outlet instead of one of the kind shown in Fig. 4, or else through the bedding and sieve into the hutch below, whence it can be drawn through a proper gate.

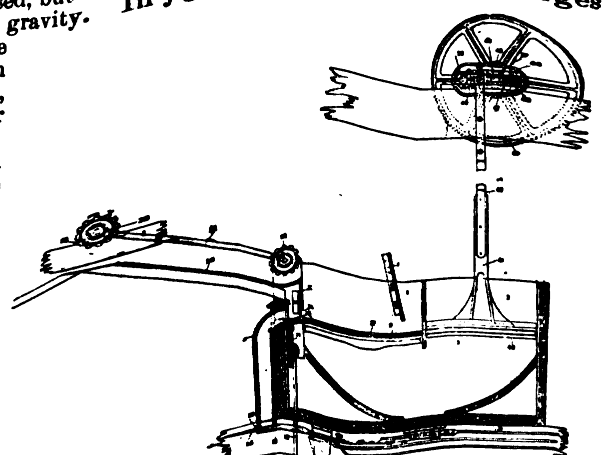


FIG. 4.—Coal jig.

Automatic Slate-Pickers.—These depend for their action upon the fact that, while the coal generally breaks into cubical masses, the pieces of slate of the same length and width are of very much less thickness. Hence, if a quantity of slate and coal which has been passed through a screen and properly sized, the slate, if placed edgewise, would drop through a slit over which the coal would pass. There are two types of automatic slate-pickers: one, intended to be placed in a chute and to be fixed; and the other, to be placed in the discharge-slip of a gyrating screen and gyrated.

The fixed slate-picker consists essentially of a series of V-troughs of iron cast in one piece, one side of the V being shorter and at right angles to the other. The lower half of the casting has a taper slit in the short side. The slit is so arranged that anything lying on the long side of the trough and of not too great height can slide out through it. Any lump which is thicker than the height of the slit will of course be retained in the trough. The slits widen as they approach the lower end, and the part of the casting below the cross-bar hangs freely, so that there is nothing to stop a piece from sliding through the slit. This slate-picker is placed in an ordinary trough or chute down which the coal slides. It receives pitch enough to allow the coal to slide over freely, but with not too great velocity. As the coal and slate come down the chutes, each lump places itself in one or other of the grooves or troughs, which are made a little wider than the largest lump of the size for which the slate-picker is to be employed. As the lumps slide down, all the flatter pieces tend to pass out through the slit on the side, while the cubical

lumps go over. Should a piece catch in the slit in consequence of the increase in height toward the end, some one of the pieces which follow will generally knock it loose, so that it does not remain and block the slits. The slits if made parallel would soon clog. The flat pieces, which are mostly slate, and which fall through the taper slit, pass over a chute or picking-table or any convenient place, where they are examined by a boy, who takes out any flat coal that may come through with the slate. The size and taper of the slit, the pitch of the picker, the width of the troughs, the length of the upper and the lower portion of the casting, vary with the size of the coal, nature of slate, etc.

The Gyrating Automatic Slate-Picker is made in the same way, with this exception, that only the part with the slit is used. This is placed on the discharge-chute attached to a gyrating screen. The pickers are made in two patterns, to be used according as the screen gyrates in one direction or the other. They must be so arranged that the gyrating motion of the screen has a tendency to throw the coal and slate against the short high side. In this way the latter is thrown out and passes to a jig or picking-table.

A third method of removing slate mechanically is used in several breakers in the Wyoming region. It consists essentially of an inclined plane, down which the lumps of coal and slate are allowed to slide freely. The plane may be covered with iron, stone, or slate. The angle is such that the slate will slide down uniformly while the velocity of the coal increases. There is a gap at the end of the inclined plane, over which the coal jumps by virtue of the greater velocity acquired in sliding down the plane, while the slate, moving slowly, drops into it. There are a number of devices for changing the pitch of the chute, the form of the opening, etc.

COAL-MINING MACHINES. The principal inducement to operators to use coal-cutting machinery in preference to mining by hand-labor is naturally due to a reduction in the cost of getting out the coal to be gained by the former method. With it, it is possible to effect a larger saving of coal than is possible by hand-labor, due to the small height of the undercut; also the number of men which have to be employed can be materially reduced. To get out the same amount of coal it is not necessary to keep as many working-places open in mines using machinery as it would be when employing hand labor, thus making it possible to have the working-places more concentrated, and thereby to save a large amount of expense in the form of dead-work, such as keeping open gangways. To give an approximate idea of the cost of mining with machinery as compared with hand-labor, it can be stated that a coal-cutter in the Hocking Valley is capable of giving an output of 80 to 85 tons a day. The price now paid for cutting coal by machines in rooms is 8 cents per ton; the price paid for loading coal after the cutting is 35 cents per ton. A miner can mine and load on an average 8 tons per day, being paid 70 cents per ton. This shows a cost of 43 cents per ton of coal mined by machines, against 70 cents mined by hand. To the former will have to be added wages for one engineer, fuel, interest and depreciation, and wear and tear of the plant. By working the machines day and night, however, these last items can be reduced to a minimum. This policy is being followed in most mines using machinery, as it enables a comparatively small machine-plant to give a large daily output. For example, should an output of 800 tons per day be required, and the machines be worked during the day only, ten coal-cutters (with the necessary engines), etc., would be required. By working day and night, five coal-cutters would be sufficient, as well as engines, generators or compressors, and ducts of half the size. The work of loading and hauling would be done during the day only. There are at present two general styles of coal-cutters in use; those using rotary cutters and those using reciprocating cutters, both of which have special features, which make it advisable to use one or the other, according to the nature of the coal.

Rotary Coal-Cutters.—The general features of rotary coal-cutters are as follows: the undercut is made by means of revolving tools, the axis around which they revolve being either a horizontal line parallel with the coal-cutter (cutter-bar), a horizontal line at right angles with the coal (augers), or a vertical line (chain-machine).

The machines in general consist of a stationary bed, upon which slides a movable frame bearing the cutting devices. The latter is gradually fed into the coal as the knives or tools cut the coal away in front of it. The motor (either compressed air or electric) is attached to the movable frame or to the stationary bed, suitable gearing transmitting the power to the cutting devices. The feed is automatic, and consists either of a screw and nut or rack and pinion. The best speed for feeding seems to be from one ninth to one tenth of an inch per revolution of the cutting devices; although for some coal this speed might be increased with advantage. An important feature of this style of coal-cutters is a proper device for withdrawing the coal-dirt or slack from the cut, to prevent the knives from becoming clogged.

In the room and pillar work in use in this country the coal is generally undercut the entire width of the room to a depth equal to the height of the vein. It takes about nine or ten cuts to accomplish this in a room 30 ft. wide. After the undercut is made, from three to four holes are drilled in the coal about two thirds of the height from the floor, but varying with the condition of the vein. These holes are filled with powder, and the coal shot down. After having been blasted down, the coal is loaded into the mine-cars by a set of miners, and the room is cleaned up for another set of cuts. While the process of drilling, blasting, and loading is going on, the coal-cutter is taken into another room prepared for it, and there again undercuts the coal the entire length of the room. The best part of the coal is generally at the bottom of the vein, and it is therefore desirable to save as much of this as possible. For this reason the "bearing-in," or cut, is often made in the fire-clay underlying the coal, if this is not too gritty, or in a slate-parting in the coal. If the latter is high up in the vein, the

machines can be worked from the bench—in other words, if the coal underlying the parting is allowed to remain down for a sufficient distance from the face of the room to allow the machines to rest on it while making the new cut. When undercutting in fire-clay, care is generally taken to cut partially in the coal, as the white clay adhering to the latter would decrease its value in the market. Wherever neither a suitable parting in the coal nor a fire-clay bottom exists, and it is desirable to get out the largest amount of lump-coal possible (especially in some of the small veins), the height of the cut has to be made as small as possible; it is, however, not advisable to reduce it below 3½ in., as otherwise it may not allow the coal to tumble over properly when shot down.

The amount of work a machine is capable of performing in a given time can be expressed in tons only when the thickness of the vein and the amount of impurities in the shape of partings, bony coal, or slate, etc., are known. A better method of designating the amount of work the coal-cutter is capable of performing in one day is by giving the number of cuts it can make, or the number of sq. ft. it can undercut. This daily work, of course, varies somewhat with the nature of the coal, whether the latter is hard or soft, or contains sulphur or bastard, the width of the workings, and the territory to be covered by one machine. The largest record so far made with rotary coal-cutters is said to have been 52 cuts in ten hours, or 950 sq. ft. undercut. The average work in the same mine in wide workings is 35 cuts, or 645 sq. ft., for narrow and wide workings 30 cuts, or 555 sq. ft.

When handled by expert men, and with not too hard coal, machines can make about 30 to 35 cuts a day in from nine to ten hours, making it necessary to prepare at least four rooms for each to work in.

With the exception of one type, all the rotary coal-cutters used in America are fastened down in proper position at the face of the coal to be undercut. They then make a cut in the coal to a certain depth, and of a width depending on that of the cutting device. The latter is then withdrawn, and the whole machine moved sidewise, and placed in position to make another cut adjoining the former. The time consumed in shifting the machines averages about 1½ min. To reduce this lost time as much as possible, it is advisable to undercut as many square feet as possible with one setting of the machine. There is, however, no advantage in making the cut deeper than the vein is high—that is, in a 5-ft. vein the cut would be 5 ft. deep, as otherwise the coal will not "shoot" down properly and tumble over. If the coal simply settles down in its former place, it is in a worse condition for mining than if it had not been undercut. Neither is it advisable to make the machines longer than required for the 6-ft. cut, as they would become too unwieldy. It is necessary to make the cut as wide as possible, so as to reduce the number of times the machine has to be shifted to cut the coal in a room of a certain width.

Handling Machines.—Coal-cutters are generally handled by two men only, and for this reason it is necessary to reduce the weight of the machines as much as possible. It must also be borne in mind that they are not only handled very roughly, but have to do very hard work, being at times forced through coal containing small streaks of sulphur, or other impurities, harder by far than the coal itself. Should these foreign substances occur very frequently in the "bearing-in seam"—that is, in that part of the coal in which the undercut is to be made—the reciprocating coal-cutters, of course, would be the proper machines to use. If, however, only small streaks of sulphur occur, the rotary coal-cutters are generally forced through them.

The main feature of a successful coal-cutter is great strength. To show that this is of far greater importance than lightness, the record is given of the time required to shift a 3,000-lb. machine, 36 seconds being the average time in six tests to shift the machine from one position to another. This, of course, is exceptionally quick, and it is not to be expected that men would be able to keep it up all day. This machine is probably the heaviest on the market, the motor alone on it weighing about 1,700 lbs.

It is hardly reasonable to expect that the machine can be shifted in less than a minute and a half as average for a day, no matter how light it is made, and this is being easily accomplished by expert men with machines having the abnormal weights given above.

To convey the machines from room to room they are mounted on small trucks and hauled by mules or horses from one place to the other. These trucks are generally provided with a suitable winch and chain, by means of which the machines can be readily loaded. The average time to do this is about 2 min. 45 sec.; the average time to unload the coal-cutter is 2 min. 35 sec.; and to get the machine ready for the cut will take 3 min. A quick record for this work is 1 min. 45 sec. to load, 1 min. 30 sec. to unload, 1 min. 26 sec. to set and get ready for the cut. The time required to move the machine may be estimated as from 40 to 50 sec. for each room between the one cut and the one to be cut, although it may take all the way from 10 min. to an hour before a mule can be secured for this work. A truck so constructed that it can be operated by electricity in mines using the latter for power purposes is, therefore, very desirable.

Reciprocating Coal-Cutters.—The second style of machine used in America is the reciprocating coal-cutter. This is not capable of quite as rapid work as the rotary cutter. It has, however, some features which make it well adapted to certain kinds of coal and certain conditions. It has already been said that when the quantity of sulphur or similar substances is not too great in the bearing seam of the coal, the rotary cutter can be used. Should sulphur occur in large quantities, and in the shape of what is called "sulphur balls," or "nigger-heads," it will be necessary to use reciprocating cutters. Another reason for using the latter machine in preference to the former in small veins can be found in the following:

are paid for the amount of lump coal mined. The small sizes screens having bars from 1¼ to 1¾ in. apart—namely, nut, pea-fit to the operator. In these districts the royalties on the coal lump coal mined. Whenever the small grades of coal. there-may be to the advantage of the operator to get out as much of e sizes as possible; and this can be done by means of the punch-or reciprocating cutter. All the coal coming out of the cut e by the rotary machine is in the form of fine slack, and is not ketable; that coming out of the cut made by the punching-aine is generally in the shape of nut or pea coal. It is also ssary to make the height of the cut with the latter machines er than that made by the rotary machine, to enable the tool to it and to undercut the coal to the proper depth. We present ous improved forms of drills and coal-cutters.

rim's Coal-Drill (Fig. 1) is a simple form of hand-tool. n in position, the post is fastened securely to the roof and the of the mine. The nut through which the screw-rod turns is ed in any of the slots cut in the post in order to get the proper of hole to be drilled. The steel bits slip into the socket at nd of the screw-rod, and are made in different lengths to suit d—for instance, if a 6-ft. hole is to be drilled, a steel bit 2 ft. eplaced by a steel bit 4 ft. long, and finally by one 6 ft. long. made with 6, 8, 10, ange which fits the or rock.

d *Reaming* (Fig. 2) g into coal-banks. an expansible bit, r normal position When a previously he bit is expanded of the bore for the powder. ed vertical section auger-casing. The longitudinal face-om end to end, and ity a socket is fast-of the guide-box a the drive-shaft by hub and entering his means when the shaft, the latter is a hole has been drilled the desired depth, a thumb-screw is p tightly to the frame and stops the forward movement of the casing from turning. By further manipulation the casing becomes stationary and forces the bit-rod outward, thereby causing the bit-members to expand. When the pocket has been properly formed, the bit-rod is drawn backward, the bit assumes its normal position, and may be readily removed from the hole.

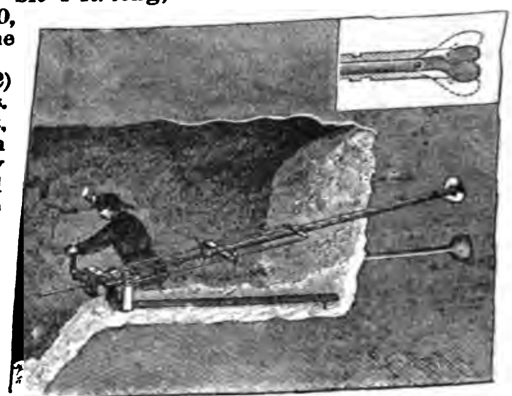


FIG. 2.—Watts' drill.

The Jeffrey Positive-Feed Coal-Drill consists of a small rotary engine hung in an upright frame, having joints at top and bottom to engage by adjusting screws with the roof and floor of the mine. This is supported by a dog or brace, to stiffen and hold the frame rigid as the auger-bit advances into the coal. Power is transmitted to this auger-bit or feed-bar through two gear-wheels. Attached to the engine are feed-nuts that open and close upon the feed-screw, which is 4 to 5 ft. in length, on one end of which is a square socket, into which is inserted the square end of the auger-bit. Two bits are used for convenience, one 3 ft. and the other 6 ft. long,

Feed drill.

...lachine.—Fig. 5 embodies a direct-acting engine mounted upon ...g upon a board which is inclined toward the face of the coal. A pick shaped like a fish-tail is attached to the piston-rod. The valve is a rotary engine, and moves constantly and uninterrupt-...edly when the throttle is open, whether the piston is stationary ...r in motion. Two handles are attached to the rear of the cylin-...er, which are used by the operator to direct the machine. The ...perator sits on the board, places his feet against the wheels, and ...kes hold of the handles. A channel is made under the face of ...e coal. The machine requires a maximum of 16 cub. ft. of air ...r minute at 45 lbs. pressure to run it, and an average of 15 ...b. ft. each per minute when several machines are being run ...om one main pipe at the same time, which is fed to the machine ...rough a 1-in. four-ply hose. The projectile weighs from 60 to ... lbs.—according to the length of the rod—and strikes from ...0 to 210 blows per minute. The total weight of the machine ... from 570 to 620 lbs. The makers claim that from 25 to 50 sq. ...ls. of floor is the ordinary amount undercut by one machine ...ch day. It has often undercut from 6 to 8 sq. yds. of floor per ...our, cutting time, but all lost time for moving and other con-...ngencies are included in this statement of a day's work.

The Sergeant Coal-Mining Machine (Fig. 6) is made in two ...zes: the standard machine—weight, 700 lbs.; length, 7 ft. 6 in. ...ver all—which will undercut to a depth of 4½ ft.; and the light ...ining-machine—weight, 500 lbs.; length, 7 ft. over all—which ...ill undercut to a depth of 5 ft. The light mining-machine is ...5 in. high, and will mine coal from a 16-in. vein.

The distinctive features of this machine are as follows: No ...otary or reciprocating engine is used to operate the valve, but a ...uplex slide-valve system, consisting of two valves in the same ...hest, independent of the action of the main piston. This valve ...otion is positive. Having no dead centers, it starts on turning ...n the air, and has no outside hand-wheels or moving parts. ...he stroke is made variable both in length and strength, and the ...orce of blow and length of stroke are under instant control of ...he operator. The picks are of forged steel, with shanks made ...quare and of full size where they enter the socket. Balancing ...s effected by loosening one nut and slipping the hub backward ...r forward in a slot cast in the side of the cylinder. The piston ...s made of forged steel, and is corrugated to prevent rocking or ...wisting. It is held in place by a composition metal sleeve ...which is bolted into the front head. The wheels are provided ...with large hub-bearings—4 in. in diameter—which eases the effect ...f the blow on the operator, and obviates lost motion. The ...movement back and forth on the board while running at full ...peed—190 to 250 double strokes per minute—is about ¾ in. The operator can swing the machine and direct the blow with ...ne hand, and can work either right or left handed. The ma-...chine requires but little space and can be used successfully in ...narrow veins, around and between props, and wherever a miner ...can swing a pick.

The Jeffrey Electric Coal-Mining Machine is represented in ...ide view with the cutter-bar withdrawn, in Fig. 7. It consists ...f a bed-frame occupying a space 2 ft. wide by 8 ft. 6 in. long, ...omposed of two steel channel bars firmly braced, the top plates ...n each forming racks with their teeth downward, into which the ...eed-wheels of the sliding frame engage. Mounted upon and ...e is a sliding frame, similarly braced, consisting mainly of two ...ounted at the rear ends one electric motor, from which power ...ght gear and worm wheel to the rack, by means of which the ...l Upon the front end of this sliding frame is mounted the ...steel shoes, with brass boxes. The cutter-bar contains bits, ...e by set screws. When the cutter-bar is revolved, these cutters ...The cutter-bar is revolved by an endless, curved-link, steel chain ...s it is revolved, is advanced by the above mechanism into the ...undercut to the desired depth. The current required is from ...e of 220 volts; each motor is wound to develop fully 15 horse-...some veins of coal the machine only uses 30 ampères, or 7½ The armature of the motor is calculated to run at a speed of ...rom which the speed is reduced, so as to run the cutter-bar 200

...*Machine* is represented in Fig. 8. The machine is operated by ...ic power. It consists of a stationary frame held to the floor of

labor, $0.357; officials and clerks, $0.028; supplies and repairs,
al, $1.667. The average amount of coal necessary to make one ton
.10 lbs. With these figures the results obtained with the improved
lowing paragraphs may be compared:
n, which is extensively in use in Europe, is designed for coking
ey are usually built in series of 30 or 40, and are worked in pairs.
) ft. long, 18 in. wide, and 4 ft. high, have each 28 vertical flues lead-
h the partition-wall common to two ovens, to horizontal flues that
ath the chambers. In these horizontal flues the gases from a freshly
those from one in which the coking is nearly complete, and combustion
ted through three small openings. At each end of the oven are two
harge is completely coked, it is pushed out of the oven through the
engine and ram placed at the opposite end, this operation requiring
The lower doors are then closed, and a fresh charge of coal fed in
the roof, which are covered by sliding doors. The charge is next leveled
e upper-end doors closed, and the operation resumed; the whole time,
s to discharge to closing them after a recharge, being but eight minutes.
4 hours, and the ovens are charged alternately at 12-hour intervals.
Coke-Oven (Figs. 1 to 4), which is designed to save the by-products
hat similar in construction to the Coppée. There are charging-holes,
a, a′, a″, in the roof of the oven, which is from 2 ft. to 2½ ft. wide and 5½ ft. to 6½ ft. high. The gases are drawn off through a pipe, *b, b′, b″*, which is provided with a regulating valve, whence they pass into a system of pipes common to from 30 to 50 ovens, kept cool by jets of water, in which the tar and ammoniacal liquors are condensed. The lower open end of the condensing pipes dip into a collector for the products of condensation, similar to those employed in gas-works. The gases from the condenser are then passed through scrubbers filled with wet coke, where the last traces of ammonia are removed. The uncondensed gases pass onward to the oven for heating purposes, entering through a horizontal aperture, *c, c′*, in the basal flue of the oven above a grate, *d*, that is filled with ignited coke-dust, while the air for combustion enters from below through the grate. Under the base of the oven the burning gases pass to and fro once, then rise between two adjacent ovens to the uppermost of the side-flues, *e, e′, e″*, and pass gradually downward to a large flue, *f*, which conveys them

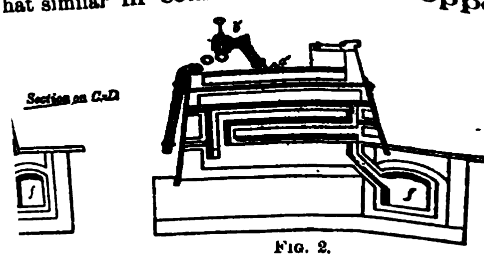


FIG. 2.

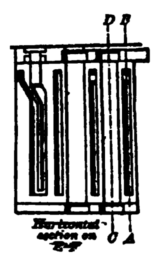


FIG. 4.
rvès coke-oven.

duration of the coking is from 60 to 72 hours, in ovens of the smaller
ke is said to be 75 per cent. At the Bessèges iron-works, in France, in
oal were coked in 85 ovens of this type. The amount of coke produced
0·55 per cent, together with 1,096 tons of tar (2·23 per cent) and 4,399
quor. The net gain, after deducting all expenses, and not counting the
The consumption of coke-dust on the grate did not exceed 35 lbs. per

t Simon-Carvès ovens the fireplace and grate are dispensed with, and
sively with the gases escaping condensation, these entering the lower
e the hearth used to be, while air is forced in through an annular pipe,
ted to 500° or 600° by being brought in contact with the hot flues convey-
vay from the ovens. The two lower flues are thrown into one, and at the
he greatest heat is sustained, the walls are lined with fire-brick. The
nto the bottom flue is purposely insufficient for complete combustion of
ere, the further supply of hot air being obtained through the side-flues
unt thus admitted being controlled by dampers. These ovens are made
1, and 19½ in. wide. Their capacity is about 5 tons of coal per charge,
sting 48 hours. The cost of a Simon-Carvès oven to work about 480 tons
capacity of an ordinary beehive oven, is $845, complete with the coolers
An ordinary beehive oven of this capacity costs but $280. At Dyson &
ery (Durham, England), according to Mr. S. A. Tuska, in an article "The
Process" (published by the author), a battery of 50 ovens cokes about
veek. The analysis of this coal is as follows: Volatile matter, 27·69 per
8·44 per cent; sulphur, ·77 per cent; ash, 3·10 per cent. The yield in
ent; sulphate of ammonia, 9 tons per week, equivalent to ammoniacal
the coal, and of tar 6½ to 7½ gals. per ton of coal. The cost of labor for

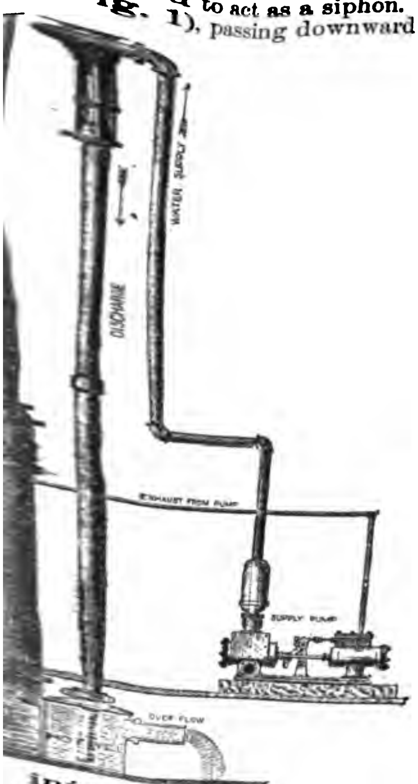
in convenient positions. The coking-chamber E, with
ed back and base, and large discharge opening in front,
openings $f\ f^1$, arranged at various heights, with the
es are mixed with air admitted from the outside through
as of high heating power, which, by way of passage h, is
along the back of the coking-chamber, and then through
g by their combustion the upper part of the walls of the
scharged through the passages $l\ l$ into the main flue i^1.
etort gases is heated by passing through long passages in
the amount of air can be carefully regulated by slides.
e provided near the top of the ovens at H^1, and the com-
in their flow to the chimney by valves at i^2. Fig. 1 is a
on, and Fig. 2, through the coking-chambers. Forty of
s of the Carlton Iron Co., Ltd., in 1888 (*Engineering and*
actual results of their work special trials were made in
sed, of which 65 tons 16 cwt. was washed East Howle coal
ons 4 cwt. unwashed coal from various collieries, varying
ng a large amount of volatile matter. Out of a total fixed
69·44 per cent was returned as coke, the time required for
ortion of large to small coke was satisfactory, there being
l of 86 tons of coke obtained from 124 tons of coal. This
er, considerably reduced, it is stated, in places where the
of the coke from the ovens to the trucks. The traveling
chain, supported on rollers and so arranged that it travels
ning of the ovens. When the door of a chamber is opened
f the coking-chamber, with but very little assistance from
here it is quenched by water-sprays. The belt discharges
ng, into the trucks; thus a great saving of labor is effected,
ding to a group of 40 ovens. The experience so far gained
gh temperature obtained in the regenerative flues by burn-
ixture of atmospheric air, coals of almost any composition
ures be used to produce sound hard coke suitable for blast-
he volatile gases are utilized to produce the necessary heat,
is converted into coke, while in addition any of the vola-
ng process may be condensed and utilized for by-products.
oven, has found that about 16 per cent of gases is neces-

lly a combination of a coking-chamber with the Siemen's
, serving for the combustion of gas to as high a degree as
sed through a condenser, as is done in all cases where the
d, it is necessary to compensate for the cooling of the gas
ture as possible for combustion with the gas. The Otto
neath which are the regenerative chambers connected by
rs, and equipped with the usual arrangement of reversing-
s and heated air from one regenerator takes place in one
t gases and flames rising through the vertical side flues
s, and escaping by the other half of the bottom flues and
s is reversed periodically in the manner usual with Siemens
ave openings at each end for withdrawing the coke, three
two for the escape of the gases given off in coking. These
lves communicating with the main gas-pipe or receiver.
Iron and Steel Institute, vol. ii, 1884, p. 520) that the re-
in, in the working of these ovens, a temperature of 1,800°
s found unnecessary to use all the gas given off from the
nan coke-works, out of 24,700 cub. ft. of gas produced per
. ft. were required for combustion. The bottom and side
arge of 5 tons 13 cwt. of dry coal the coking process lasts
With Westphalian coal the ammonia, reckoned as sulphate
to 1 per cent of the weight of the coal. The yield of coke
from one coking-works amounted in seven months
to an average of 3 per cent of the weight of coal
used. By the daily treatment of 2 tons 14 cwt. of
coal per oven, sufficient waste heat is obtained from
every oven to heat 54 sq. ft. of boiler surface, which
corresponds (according to Dr. Otto) with an evapo-
ration of 1 lb. of water for every pound of coal coked.

The Aitken Coke-Oven (Fig. 9) is a beehive oven
fitted with two pipes, a, a', for conveying the blast
and gas from the condensers through small holes
in the roof distributed equally around its circum-
ference. Channels, b, b', b'', in the floor of the oven
l to a pipe, c, which leads them to the condensers. The
t. high, from the floor to the charging hole in the roof.

Metal-Working. **Cold Storage**: see Ice-Making Machines.
…pinning Machinery.
…suring Instruments.
Air, Compressed.
…aporator and Ore-Dressing Machinery.
…-Gin, Ice-Making Machines and Engines, Steam.

Bulkley Injector-Condenser is of the injector form, with its water … arranged to act as a siphon. The condensing-water enters by the … it (Fig. 1), passing downward around the exhaust-nozzle in a thin circular sheet. The exhaust-steam thus enters a hollow cone of moving water, and is condensed. The water then passing down with great velocity through the contracted neck of the condenser draws with it the air and vapor into the discharge-pipe below. The general arrangement of the condenser and its pipes is shown in Fig. 1.



…injector-condenser.

Hill's System of Condensation for Pumping-Engines (Fig. 2) provides an ordinary surface-condenser arranged to take water from either the suction or discharge pipe of the main pumps, which water, after it has effected the vacuum in the condenser, is returned to the pipe from which it was taken. By the regulating-valve the amount of water passing through the main which is diverted into the condenser is regulated so that the least water capable of producing a given vacuum shall pass through the condenser, in order that the temperature of the hot well or water delivered from the condenser by the air-pump shall be as high as possible (this water being used as the feed to the boilers). By delivering more water to the condenser, a better vacuum … esponding reduction in the temperature of the contents of the … s shown that the gain in economy by the improved vacuum is … by the reduced temperature of the feed to the boilers, and that a

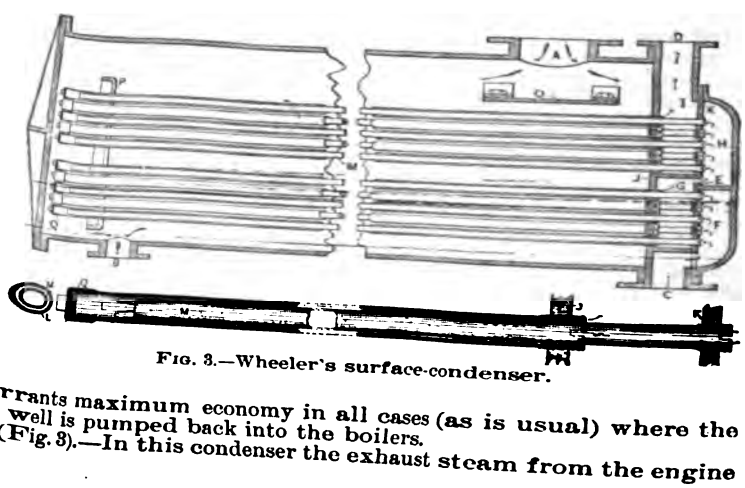
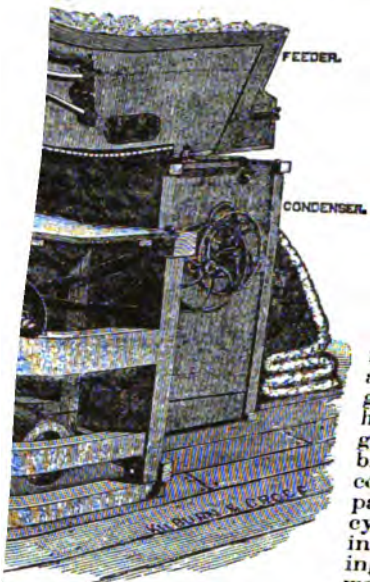


FIG. 3.—Wheeler's surface-condenser.

…warrants maximum economy in all cases (as is usual) where the …ot well is pumped back into the boilers.
…r (Fig. 3).—In this condenser the exhaust steam from the engine

is shown in the sectional view (Fig. 2). Among the new hollow, and an arrangement of the breast, which it is claimed prevents breaking of the roll. The object sought also was a perfectly smooth seed-board, presenting no angles to interfere with the easy turning of the roll. The bottom is formed of an iron plate sufficiently strong to hold the weight of the roll. This plate is attached to the body of the seed-board with hinges at its top edge, so that the bottom edge, which is notched to correspond with the saws, may swing in or out. The feeder is arranged on top of the gin. The feed-cylinder has the same speed as the gin-saws, and has strong, blunt pins to bring up the cotton. Behind this, and parallel with it, is another cylinder, moving slowly in the same direction, having wires in it bent backward. Between these two cylinders the cotton is completely opened, and



ie gin.

ng them in such condition that the gin will easily dis-
king out a large amount of leaf and dirt. The condenser
th cloth, and having a pressure-roller over it. These are
loor, leaving a few inches of the drum uncovered, from
continu-
o be cut
ndenser,
brush is

section
s apron,
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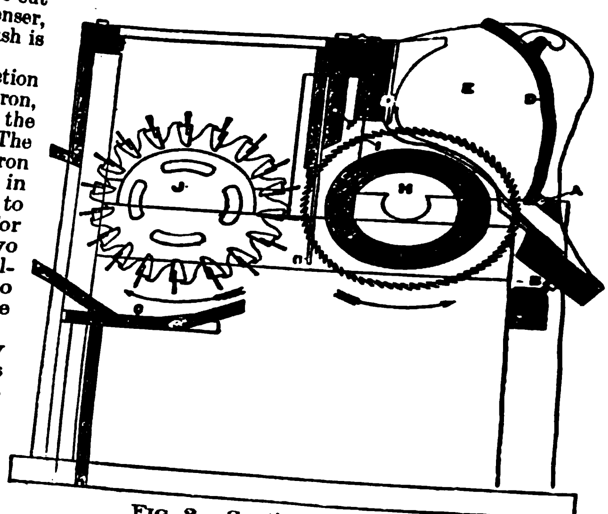


FIG. 2.—Section Eagle gin.

meant a cylindrical body for drawing out the cotton-lint
ted in place of the aggregation of saws now used in an or-
s, can be accomplished by means of a cylinder having a
are numerous openings, and in each of which openings is
extending in said opening in a circumferential direction
ided that the position of the free points or ends of said
djacent level or surface of the periphery of cylinder, the
he teeth shall be presented points forward to the cotton.
exist in front of and on each side of the end or point of

the cotton-lint, as already described, and carry the same past and under the bar F, which prevents seeds and other foreign substances being drawn around the cylinder with the lint. As the cylinder continues its revolution, the lint is removed from its teeth by the brush-wheel D, from which the cleansed material passes out of the machine in the direction of the arrow 5.

COTTON-SPINNING MACHINERY. To show more plainly the advance in cotton-spinning machinery during the past ten years, it may be well first to state in a general way the operations that are at the date of this work in use in converting the cotton in the bale to the warp on the beam, or the filling on the cop or bobbin, ready for weaving. The cotton is received at the mills in compressed bales, containing about 500 lbs. each, and generally confined by ropes or iron bands, and sacking. In this cotton is a very considerable amount of leaf, sand, and seeds, and sometimes other foreign substances. The first operation is the opening of the bales and the mixing of cotton, which is done by hand, so as to secure a comparative evenness of fiber. A number of bales are opened at once, and the mixing is supposed to be thorough. From the heap of cotton so mixed it is taken to an opener, where it is subjected to the action of beaters and fans, and delivered in rolls called laps. Two or more of these laps are then fed to a finishing lapper, where the beating operation is again gone through, and the lap from this machine is the completed product of the picker-room. The cotton at this stage has been freed from the larger portion of the foreign matter, and the fibers have been thoroughly disentangled.

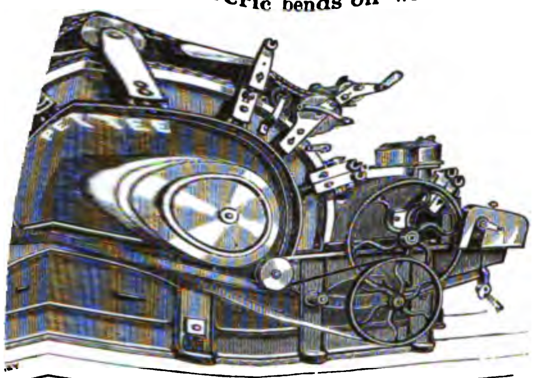
The next operation is that of carding, which is a very important one, and perhaps not yet thoroughly understood. The lap from the picker is slowly fed into the carding-machine, in which is a revolving cylinder covered with clothing, containing teeth, by which the cotton is carried past either stationary or movable surfaces, also containing teeth, and deposited upon another cylinder called a doffer, from which it is taken off in a thin sheet by a comb. The card continues the cleaning of the cotton, and thoroughly disentangles the fibers, and places them in a condition in which they can be easily straightened.

It is stated, in most books of reference, that the cards straighten the fibers; but any one who will examine with a glass the sheet that comes from the doffer will be satisfied that the fibers lie in anything but parallel directions. They are so disposed, however, that straightening becomes an easy process in the drawing to which the fibers are afterward submitted. Where carding is well done, the fibers are thoroughly disentangled, and the sheet is free from lumps, technically called mits. There are two kinds of cards in large use on cotton: the stationary flat card, and the revolving flat cord; the latter being quite generally known as the English flat card, though now manufactured by several American shops. The revolving flat card is said to do the largest quantity of work, but that is asserted by the friends of the other card to be due to the use of larger cylinders. It is also claimed that the revolving card makes less waste. There is no doubt that there is a better feed in use on the revolving flat than on the ordinary card as previously built. Another important point is this: the flats of the common card have to be raised at stated intervals to be cleared from accumulations of dirt and fiber. When they are raised an opening is left, in which the flyings from the cylinder collect, to the detriment of the work when the flat is replaced. With the revolving flat the cylinder is always covered, and the flats not in use are thoroughly brushed out, between their service at the rear side of the cylinder and their next service at the front side. The cotton leaving the card is, with the revolving flat card, gathered together into a strand, and run into a can. Where the ordinary card is used, the strand is fed into what is termed a railway-box, where, with other strands, a sheet is formed, which is carried by a belt to what is termed a railway-head, where it is reduced in size of strand by drawing-rolls, and subjected to the action of an evener.

The next operation is known as drawing, which is done to complete the straightening of the fibers of the cotton and to reduce the sliver, the technical name for the strand in this condition in size. Besides this, the strands are doubled over and over again before being drawn, to equalize the diameters of the resulting strand. The theory is that by doubling, large places in one strand are likely to come opposite small ones in another strand, and the general average of size be improved. Too much drawing, however, weakens the material, and there is considerable question among manufacturers as to the proper amount. Where the English card is used, the cans from the card are set up behind the drawing-frame; and where the railway-head system is used, the cans from the railway-head are placed in that position. The material is delivered from the cans on one side of the frame through the drawing-rolls to cans on the other; the diameter of cans being generally reduced with the diameter of the strands. The process of drawing was the invention of Arkwright, and it consists in subjecting the material to the operation of several pairs of rolls, the front ones of which revolve more rapidly than the rear ones, and thus elongate the sliver and correspondingly reduce it in diameter. From one to three sets of drawing-frames are now in use in most mills. The sliver at the last drawing-frame is made as small as it is sure to hold together in being drawn out of the can. To enable it to be still further reduced, it is necessary to introduce twist in the next processes. Machines by which this is done are called, in general terms, roving-machines, and their product is known as roving. These machines, like the drawing-frame, draw the cotton still smaller, and communicate twist to it by means of revolving spindles with their fliers, and wind it upon bobbins.

Of the two kinds of roving-machines in use, viz., the so-called speeder and the so-called fly-frame, the fly-frame during the last ten years has gained upon the speeder, especially on fine work. The roving, in being prepared for spinning, passes through from two to four of

ry part of the flat mechanism needs to be perfectly constructed riations may be made. Howard & Bullough have a very ingen- concentric bends on which the flats rest, which are adjusted in position by screws and inclined surfaces. Each screw has a dial with a pointer, so that by turning each dial a definite distance the bends will all be adjusted alike. They also have a new way of attaching card clothing, using no rivets. Platt Bros., of Oldham, England, have lately adopted a new flexible bend with slots and screw adjustment which admit of the direct setting by the gauge of the flats to the cylinder. They are also so arranged that the flats are ground on the under side while in position.



3. 1.—Cotton-card.

The Whitin Machine Works have endeavored to ı top flat card as to enable competition in single carding with the ard (Fig. 2) will produce 100 lbs. and upward per day of fine carding nt of waste. The sides and arches of the card are built entirely of n is simple, so that changes can be readily made. The main cylinder 8 in. in diameter, measured without the clothing. Both are accu- ɔalanced to a speed largely in excess of that used in practice. The up to either edge, securing a carding surface 87½ in. wide. The doffer is slightly in excess of this. The card is provided with 40 iron y these being greater than formerly, and equal to fully two fifths of e cylinder. The flats are now made 1⅜ in. wide, with clothed surface ied and ground perfectly true to receive the clothing, and, being heav- the possibility of warping or twisting. The ends of the flat are also correct pitch with the surface of the cylinder is accurately and uni- device for adjusting the flats consists of a square steel body terminat- in. The lower pin, having a fine thread cut upon it, passes through a d is secured on both sides of the rib by a nut. Thus any flat may be adjusted. Mortises, accurately spaced, and planed into a second rib ve the square bodies of the adjusting-pins, thus preventing any lateral g-pin is further secured by a screw passing through the square body p flat passes over the upper part of the adjusting-pin and finds a true lar turned upon the upper side of the body of the pin. They claim for and nicety of adjustment, and perfect immovability when set. A quick ips, and replaces a flat in less than four seconds, is used, and is geared torsion. A simple device is attached by which the feed may be instant- the doffer thrown out of gear with coiler and calendar rolls. Many are being changed over to the coiler system, the Foss & Pevey cards results. The latter card is being improved in addition by the use of

nbers are only used on very fine work, their field is somewhat limited. e devised to increase the production of a comber with no increase of ex- o use them to a much greater extent, as the advantage is obvious. Dob- oltou, England, have improved the Heilman comber by a change in the ig. 3). Formerly the cylinder possessed only one series of combs and one us it required one complete revolution of the cylinder to get one length e manufacturers have succeeded in introducing a second series of combs second fluted section, which doubles production at the same speed; al- d, which produces better results, and a largely increased production. The ss of preparing comber-laps has been to take slivers from the card, put process of ordinary drawing, and the slivers from the drawing were then l sliver-lap machine and made into a lap for the comber. This old process consists of a series of slivers laid side by side, and is not of one uniform has a thick and then a thin place. It is obvious that the nipper of the s well upon this lap as if the thickness were uniform throughout, and fur- thin places are there is danger of good cotton passing through into waste defective nip; also, where the thick places come, the pins are required to and the quality at once suffers.

t ribbon-lapper is used, the system is as follows: The ordinary style of rown out entirely, and the card-slivers are doubled up into a lap directly

over cones in the usual way. Railway-heads and machines in the next class have provided with steel fluted rolls, having collars to prevent the teeth meshing too

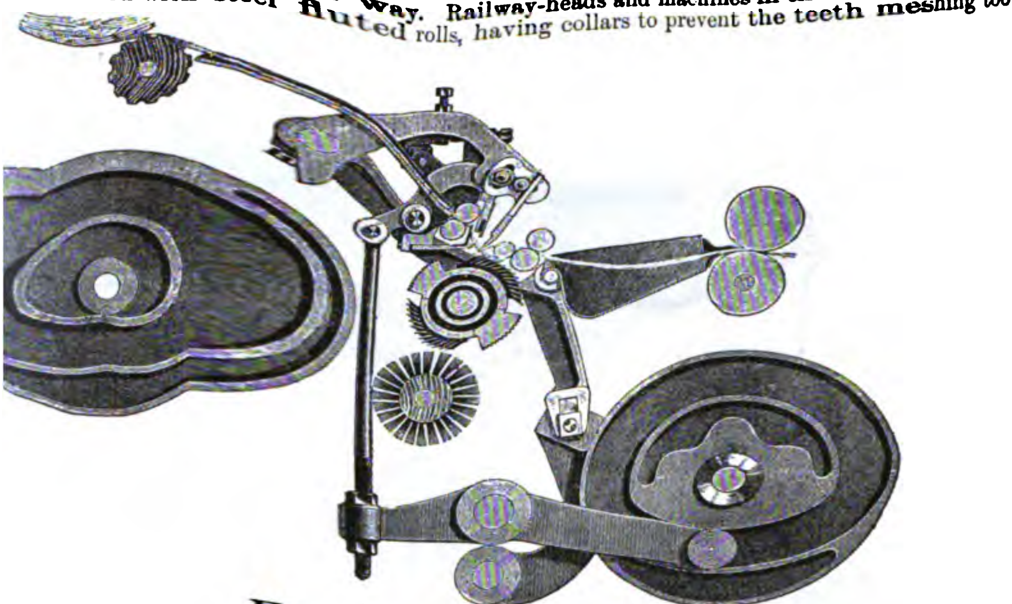


Fig. 3.—Combing-cylinder—detail.

f the common leather-covered rolls. They have been pronounced a success ces, but their use is hardly extensive enough as yet to give an opinion as to The advantages claimed are less weight required on the saddles, and no covering. This is being introduced by the Metallic Drawing Roll Co., of The drawing-frame, having come into more extended use on account of e coiler system, is receiving considerable attention.

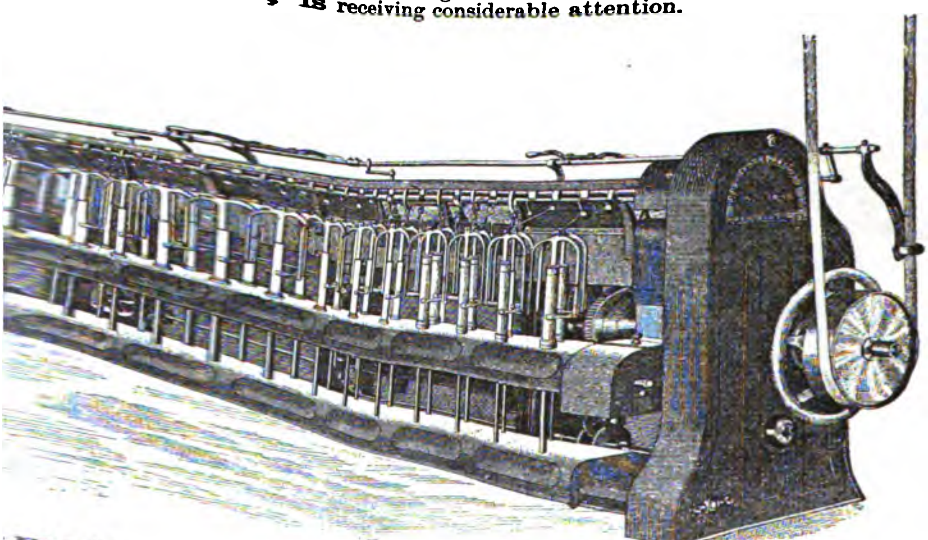


Fig. 4.—Roving-frame.

motion, as applied by Howard & Bullough, is an innovation, espe- e first successful adaptation of electricity to cotton manufacturing. nsive introduction, and as applied does more than the ordinary stop, lts, viz.: (1) A sliver breaking before it reaches the drawing rollers, t the front between the drawing rollers and coiler, (3) a stop for a full 4) a stop when cotton laps around the drawing rollers. Fales & Jenks, e the American builders of this machine. e Works are introducing a new drawing-frame with single-bossed rolls, nt on the general class.

handle per min., 45; horse-power consumed, 0·880; units of power per lb. of milk skimmed, 788·1 foot-pounds; temperature of milk, 84° to 87° F.; per cent of fat, 3·25; temperature of separated milk, 79° to 81° F.; per cent of fat, 0·45.

Two interesting forms of creamers are illustrated in Figs. 2 and 3. The De Laval machine (Fig. 2) is driven by a steam turbine, situated in the lower casing. The wheel of the Sharpless Russian machine is located in proximity to the apparatus proper.

CULTIVATORS. The superiority of surface-cultivation for corn has received slow but sure recognition. The large, deeply penetrating cultivator-blades formerly used are disappearing, and the leading manufacturers are producing new cultivators with small teeth in increased number. Fig. 1, showing a corn-plant with its roots, explains the advantages of surface-cultivation with five small teeth compared with the two large cultivator-shovels, in general demand till a recent date. The long shovels cut off the roots which nourish the growth of the ear, and act as guys to sustain the stalk erect, as the long shovels must run deep to cover the ground. If running shallow, long, large shovel-teeth merely make V-shaped scratches, neither killing the weeds nor thoroughly opening up the hard surface. The five small teeth uproot the weeds and leave no part of the surface-dirt undisturbed, yet do not seriously interfere with the tender extended side-roots of the corn-plant. To throw weeds to the surface, where they will die, instead of covering them over, as

FIG. 1.—Corn-plant and cultivator.

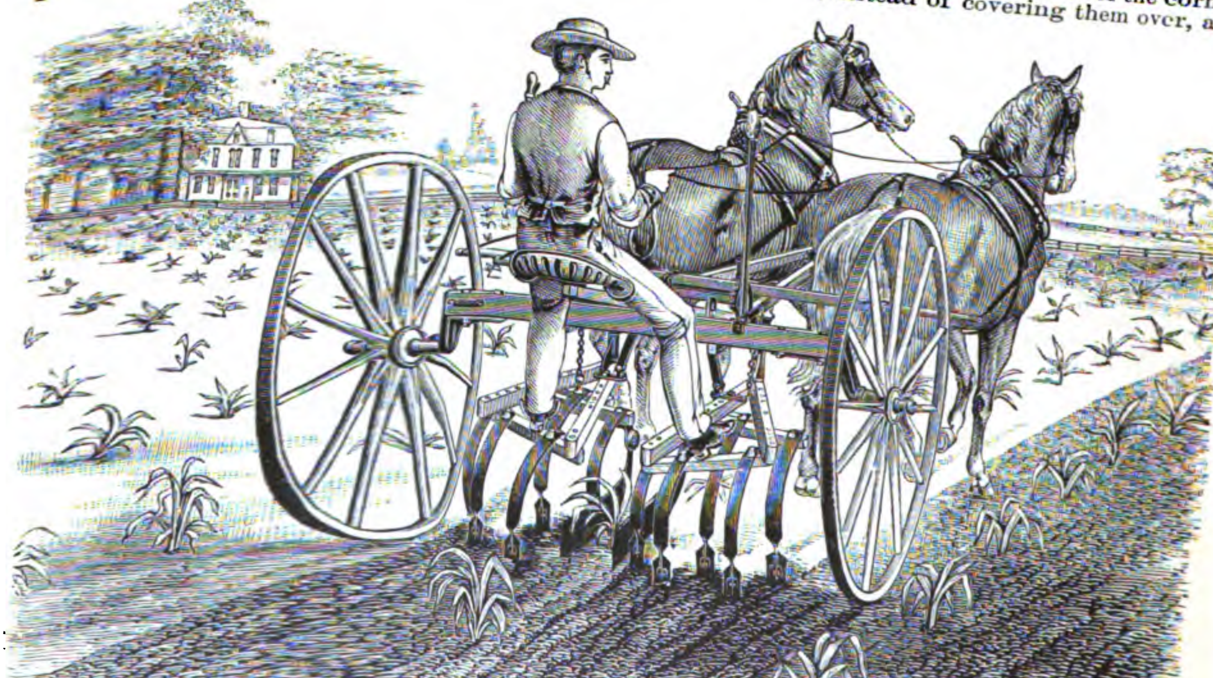


FIG. 2.—Albion cultivator.

by which it passes obstructions without the risk of breakage. The pivots a c and d are normally nearly in line, allowing the strong spiral springs to offer a very stout resistance to the flexion of the pivot c; but when the limit of that resistance is once exceeded by collision of the shovel-point with an earth-fast obstruction, a slight flexion of the pivot f causes collision of the nuption e with the rear shoulder of f by reason of shortening the distance slightly between the center of the pivot d and the shoulder, throwing the pivot c back out of line with a and d, raising the point of attachment of the extremity of the spring at b enough to nearly neutralize the power of the spring, and thus permitting the point of the shovel to yield backward and draw over any low obstacle, after which the tendency of the spring to uncoil returns the shovel to working position and relocks it. The nuption e, termed a break-pin, is adjustable, to change the amount of

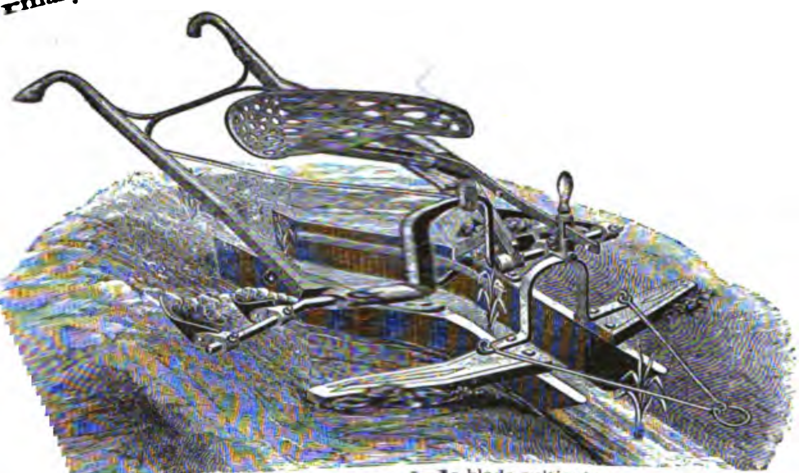


FIG. 7.—Double-blade cultivator.

istance necessary to unlock the toggle a c d, but the pivots a c d must never be adjusted in ct line, for in that position there will be no tripping, and the device will continue rigid.

The Bradley Cultivator Attachment shown in Fig. 5 with narrow paring-blades or scrapers cutting off weeds or grass below the earth surface and pulverizing the top soil, interchange- with the ordinary cultivator shovel-blades on the same machine. Fig. 6 shows Bradley's ansion arch, made in two independent parts, passing through and held in a casting on top e tongue-butt adjustably for widening or narrowing the distance between the two shovel- rs, which may thus be run close to the plant in early cultivation and farther from it after- l, while always maintaining the straight position of the shovels.

Double-Blade Cultivators.—Fig. 7 is a representative of the class of cultivators with plank- ers and two pairs of paring-blades. The runners are shod with metal, for durability. blades are reversible, to throw dirt to or from the hill or drill, and the metallic wing- ls in the rear can be raised or lowered to govern the amount of dirt passing underneath to the corn. To raise lades in turning, the pulls slightly by the rd-handle in front n, thus shifting his so that it lifts the The security of lants from injury this style of cultiva- ilable in very young id the thorough dis- f weeds by it is an ge when the season as to give weeds a the corn.

ing Cultivator.—the liar feature of Fig. 8 is r seen in front ring-lever in near iver, attached pivoted of a tongue Swaying ounds. the direc- changes independently vel steering cidental of the team: and angs can be made rooked rows and ing up hills standing out of line. On hillsides the gangs can be held from drifting The use of the lever increases the ease of turning at the ends of the rows. This n imparts more lateral movement to the front than the rear shovels, enabling the work close to the plants, with facility of control to prevent injuring them. By

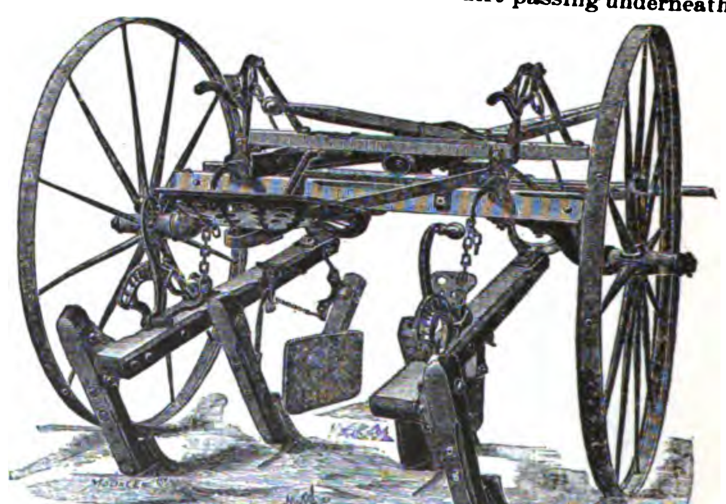


FIG. 8.—Steering cultivator.

treadles the shields are raised or lowered without stopping, governing the quantity of earth thrown to the plant according to its size.

Weir's Tongueless Cultivator (Fig. 9) is rendered light, and allows the team free move-

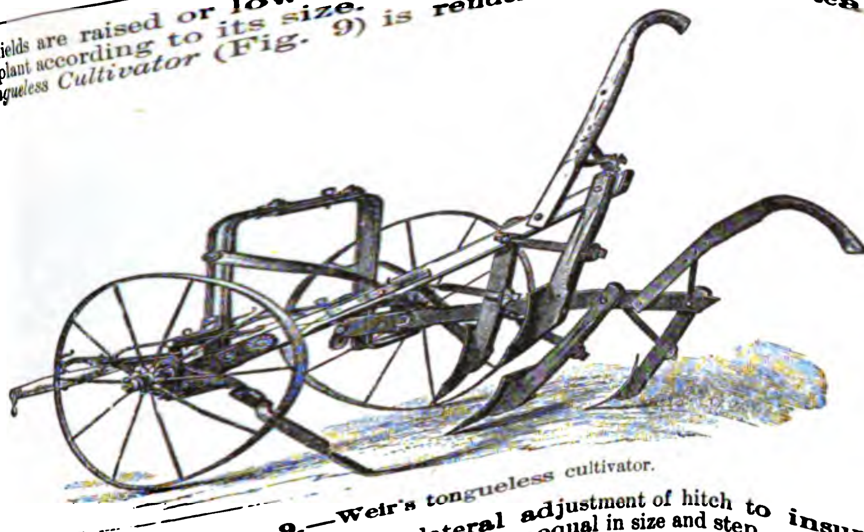


Fig. 9.—Weir's tongueless cultivator.

ment, by the absence of a tongue. It has lateral adjustment of hitch to insure the proper direction for the wheels, in case the team used is unequal in size and step.

The Deere Garden-Hoe (Fig. 10) has two short beams with handles adapted, to propel the

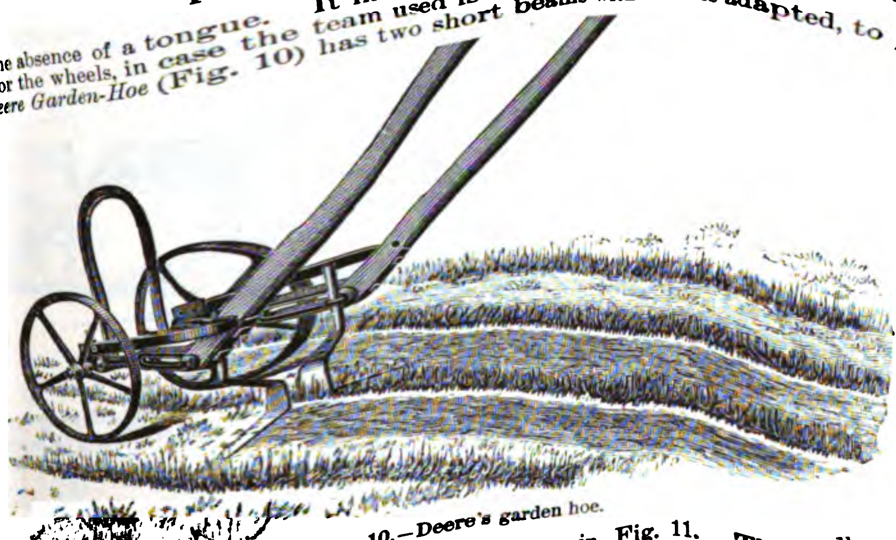


Fig. 10.—Deere's garden hoe.

machine with any of its different attachments, shown in Fig. 11. The handles are connected also with the arch in front by side-springs, permitting instant adjustment to and from

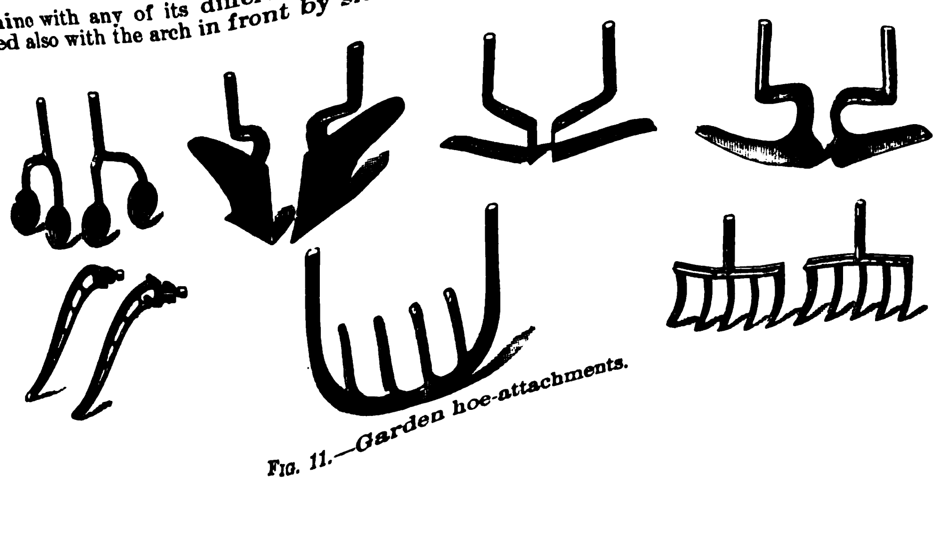


Fig. 11.—Garden hoe-attachments.

the row by the operator. A still simpler hand-implement with wheels, of the same class, is shown in Fig. 12. The two implements last named are for garden-culture.

FIG. 12.—Hand garden-hoe.

Beet Cultivators.—Fig. 13 is specially designed for beet-culture. The cultivation of sugar-beets in the United States is beginning to excite lively interest, with a view to beet-sugar pro-

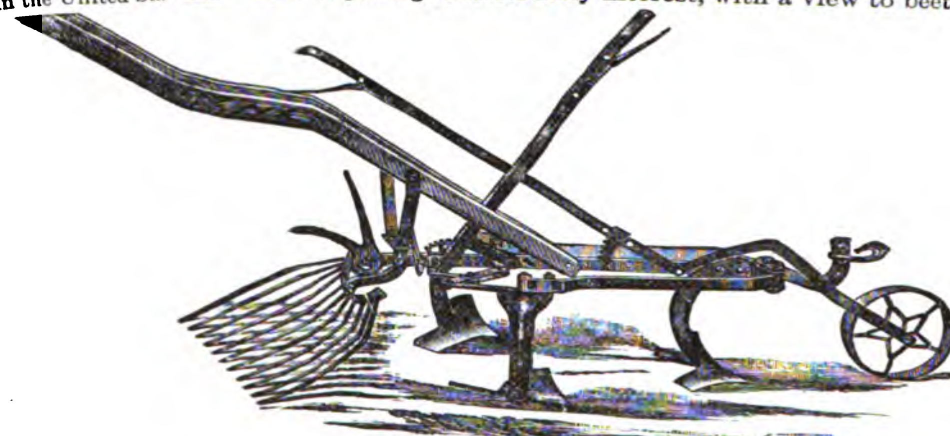


FIG. 13.—Beet cultivator.

duction. It requires thorough tilth and level cultivation—a porous soil, allowing circulation of air and moisture. To insure a mellow seed-bed the plow is run six or eight inches deep,

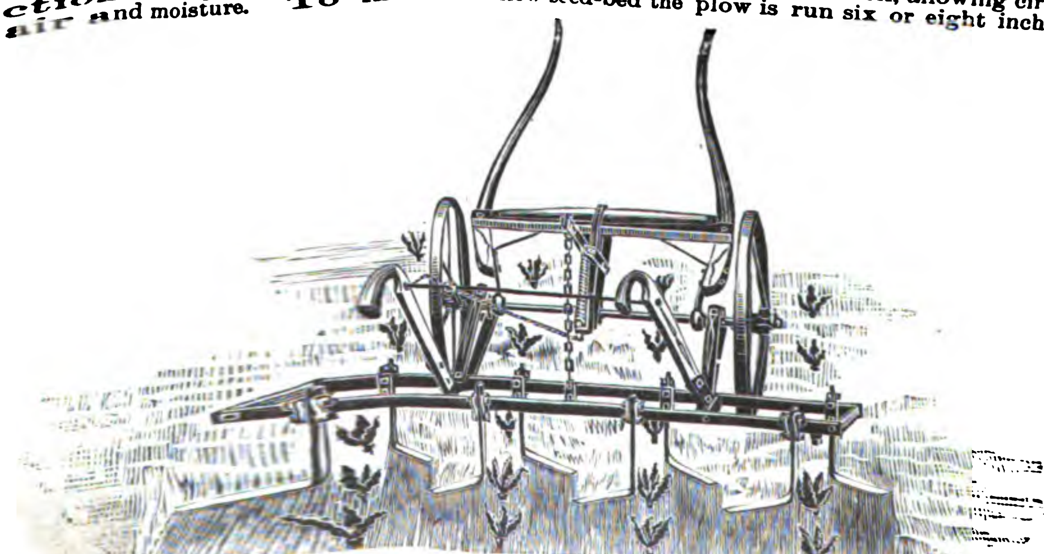


FIG. 14.—Moline beet cultivator.

followed immediately by the subsoil plow to stir the underlying soil to the depth of upward of one foot below the surface in the autumn; and thorough spring harrowing, followed by rolling, and the drills are fourteen to eighteen inches apart, one inch deep. The cultivation should be repeated every two weeks or oftener, until the beet-leaves cover the ground: when the plants may be left until ripe and plowed out from the ground. The yield of sugar depends largely on care and cultivation at the proper time. The seed is often drilled in rows and thinned out when a sufficient growth is reached. The time for thinning is when the plant shows four leaves; this is often done by driving the cultivator crosswise, cutting out surplus plants, and leaving the hills in rows. Fig. 14 is the Moline beet-cultivator, just introduced. The tooth-frame adjusts to the truck by two widely separated connections, with pivots permitting easy hand guidance, to avoid injuring the plants; and the depth of cut is regulated by a center chain inclined forward, and attached at the front end to a standard, self-locking when the handles are raised, by pawl and ratchet, and unlocked by a lanyard.

Crushers: see Clay-Working Machinery and Ore-Crushing Machines.

Curling Machine: see Hat-Making Machines.

Cutters: see Bolt Cutter, Book-Binding Machines, Coal-Mining Machines, Ensilage Machinery, Gear-Cutting Machines, Grinding Machines, Key-Seat Cutters, Lathe Tools, Metal Milling Machines, Molding Machines, Wood and Stalk Cutters.

CYCLES. The term "cycle" may be considered as generically applicable to that general class of vehicles that has aptly been called the man-motor carriage, of which the unicycle, bicycle, tricycle, and velocipede are types.

If we exclude the Johnson bicycle, patented in England in 1818 (which was a mere rolling support for the rider, placed between the legs, so that his feet touching the ground, and, moved as in walking, would carry him and his support along), the honor of inventing the bicycle is now accorded to a Scotchman, one Gavin Dalzell, some time in 1846. This wheel, said to be yet in existence, finds almost its exact counterpart in the "rover" or "safety" bicycle of the present day. Its rear wheel, 40 in. in diameter, was the driver, the cranks of which were connected by rods with oscillating foot-levers pivoted to the machine-frame; the front wheel, about 30 in. in diameter, was mounted in a fork having a slight rake, which in turn was journaled in the forward part of the frame, the upper end of the fork having a pair of handles turned rearward within convenient reach of the rider, who sat about midway between the two wheels. Pierre Lallement was the first patentee of the bicycle, in 1866. He was a Frenchman, then residing in the United States. This machine, afterward popularly termed the "bone-shaker," had the cranks placed on the axle of the front wheel, which thus became the driving as well as the steering wheel; the rider applied his feet directly to the cranks. Cycles may be classified into three divisions: ordinary bicycles, safety bicycles (including those of the dwarf variety), the Otto bicycle, and tricycles, including sociables, tandems, and carriers.

Fig. 1.—Bicycle.

BICYCLES.—The ordinary type of bicycle, illustrated by Fig. 1, hardly needs description. As it is supported on only two points—namely, its two wheels—it is necessarily unstable, and will fall to one side or the other. One of the points is movable on being turned sidewise,

, constitutes an act of recovery, caused by turning the ıchine is falling; the balance is recovered, and the equi- ually turning the wheel toward one side or the other. center of the driving-wheel, so that he is able by means ng, and to maintain his balance. the cranks in this case wheel to either side as required. This action requires, teracting stress on the handle-bar, otherwise the machine

r bicycle varies according to the diameter of the driving- er. from 18 lbs. upward. One authority distributed the everal parts in the following approximate proportions: ıt; small rear wheel, 7½ per cent; front fork with head, r cent; backbone and spring, 17½ per cent; saddle and

er the old Lallement machine has been the introduction f the machine for absorbing and lessening the vibration, ts of cycle-riding. Thus, each of the wheels is provided have been provided around the bearings of each of the s; the suspension of the seat-spring upon rubber buffers; rk of the driving-wheel, interposed between the wheel-

ntroduction of "suspension" wheels that the first real such principle of construction the wheels are very light, ucted either with solid or hollow rims, the latter being kes are direct radial spokes or tangential spokes. The n the rim and screwed direct into the flanges of the hub, threaded portion, so that the sectional area of the spoke the thread. Hollow rims are made in three ways: by drawn steel tube; by being built up of two or more strips ed section and then brazed together: and by being rolled el plate, the edges of which form a lap-joint, which are are constructed of a round or half round section, with e, and either solid or hollow. A popular form of hollow

d soft rubber, the hard forming the wearing surface and shion. The tire is generally fixed to the rim by being cemented in it. A wire, however, has been passed along the center of the tire, the two ends secured together by a right and left handed nut. Various sections of rims have also been used for holding the tire without extraneous aid. It is questionable, though, whether there is not a want of cohesion between the rim and the tire in this method.

The tangentially arranged spokes were adopted because of a certain amount of windage which takes place before the power is transmitted to the rim through the spokes. In the tangentially arranged spokes they pair being threaded through a hole in the flange of the ed to the rim by lock-nuts or nipples. One of the recent ingle instead of pairs of spokes threaded through trans- ın off at right angles to the hole, and thus form a kind eaded, to prevent them from pulling through the holes, lock-nuts.

rrugated or crimped spoke, corrugated throughout its mount of elasticity to the wheel.

w invariably made with anti-friction balls interposed be- thought that this method of easing the running parts the improved bicycle, but such anti-friction balls and d for use with axles as far back as the year 1787, and other granted in 1791 and in 1794.

ll-bearings is that known as the "Æolus" bearing, in o that the bearing remains perfectly true after adjust- ig. 3, there are two facing cones, only one of which is le-play or check. One enterprising gentleman by care- a bearing lost together $\frac{1}{20\cdot8}$ gr. in weight in running

qualing an actual surface wear of only $\frac{1}{158000}$ in.

y constructed of weldless steel tube, and consists of two backbone.

the fork, to enable it to resist the torsional strain pro-

duced by the rider's pulling upon the steering-handles, it is generally drawn and tapered into an oval section, while the backbone is of circular section, although somewhat tapered toward

Fig. 3.—Ball-bearing.

the point where it is usually brazed to the backbone. This latter is bent and blocked into shape from a blank of sheet-steel, the sides being usually of a half-round section. Frequently, however, the back fork is simply a prolongation of the backbone proper. The front fork is made rigid between the axle and front end of the backbone.

Bearing in mind that the front wheel is the steering-wheel, and that this is carried in the vertical front fork, the method of mounting and controlling the wheel must be considered.

At the top of the fork is a socket or head pivotally connected by a short spindle with the front end of the backbone, coned bearings being provided at each end of the spindle. A transverse bar having handles at both ends, and fixed upon the head just mentioned, serves to control the steering-wheel, and affords also a steadiment for the rider. A brake-handle is pivoted to the handle-bar in such way as to be easily grasped by the rider without releasing his hold on the bar. The brake now almost invariably used on ordinary bicycles is termed a "spoon-brake," and consists of a spoon-lever so pivoted in the head as to be easily brought to bear upon the circumference of the driving-wheel. The leverage is so arranged that great power is obtained, and care must be exercised in applying it so as to prevent sudden stoppage, which results in the rider being thrown off.

The saddle is of leather, and in some of the most popular types of machine is made detachable from its frame or support, which is mounted upon the backbone close behind the front fork, so that the rider's feet may conveniently reach the pedals. Different forms of steel springs are used in making up the saddle-frame, and these have an adjustable tension for riders of different weights. Devices for adjusting the saddle fore and aft and for altering the pitch of the seat are also now invariably employed.

The pedals are made in several varieties, the chief forms being known as "rubber" and "rat-trap"; they are mounted upon pedal-pins bolted to the cranks, which are in turn fixed to the axle of the driving-wheel. The rubber surfaces tend to absorb a great deal of the vibration, and also afford a good grip for the rider's shoe; the roughened steel plates in the "rat-trap" type excel in the latter particular, but lack the power of taking the vibration. A combined "rubber" and "rat-trap" pedal, constructed with rubber on one side and serrated plates on the other, is largely used, and found to give the advantage of both varieties. Two square blocks of rubber, serrated upon their surfaces, and pivoted within the pedal-frame, are also favorably known as affording adjustment to the curve of the foot. Foot-gripping devices are also used with pedals in various forms.

A peculiar and popular type of bicycle is found in that called "The Star." It has a large driving-wheel driven by pedals, which in their alternate up-and-down motion actuate ratchets formed upon the driving-axle. The rider's seat is over this wheel, slightly in front of its center, and the backbone extends downward in front, where it is forked over a small steering-wheel. The frame, including the backbone, is practically triangular in shape, with a branch for the seat-support, and this frame is so pivoted that the front wheel—besides moving sidewise in steering—may be raised from the ground at the will of the rider by correspondingly moving the handle-bar. This machine is often used for the unique purpose of playing the game of polo. The contestants, mounted upon "Star" bicycles, follow the ball to and fro between the goals, and use the small front wheel as a bat, in driving the ball in the desired direction as well as for checking it in its course.

Another ratchet-pedal action is found in the "Eagle" machine. Here the wheels are situated as in the ordinary bicycle, but instead of a rotary motion being imparted to the pedals, a simple up-and-down movement in the arc of a circle is the result of the rider's efforts, and this operates through ratchets to revolve the driving-wheel.

The accessories and fittings of bicycles, such as tool-bags, lamps, bells, lubricators, distance-indicators, etc., are too numerous in form for description; their manufacture affords employment to many artisans of different trades, and involve the investment of large amounts of capital.

Before proceeding to consider the next important form of bicycle—the "Safety"—it is necessary to look briefly at the type called "Dwarf" bicycle, this being the immediate fore-

irable cycle which permits the use of a small driving and

machine the power, instead of being applied direct to the
; through a pair of endless chains and sprocket-wheels from
ank, placed below and slightly in rear of the driving-wheel
uch nearer the ground, and his seat correspondingly lowered.
aring-up, so that the wheel may be equal in speed to any
. also allows the use of long cranks, independent of the length
its for its ease of propulsion, and consequent speed, for it is
ion in this machine is greater than in the ordinary ungeared
ly no less; therefore the theory must be that the low speed of
much exhaustion as is experienced from a more rapid movement

y be adjusted, within certain limits, to suit riders of any height,
edal-axle brackets and altering the length of the chains. By
rk pivoted to the upper branch at the center of the wheel, and by
ngle and then tightening-up, the height of the pedal-axle from
ithout altering the length of the chains.
so propelled by a lever-action, and this type is commonly known
ently as "Grasshoppers." The fork of the front wheel is extended
on the ends are pivoted two pedal-levers, worked at their free ends
levers work the cranks or the wheel-axle through connecting-rods
the leverage. The action of the feet is a reciprocating one, the
simply the arc of a circle, of which the radius equals the length of
ations of the rider's feet are just equal in number to the revolutions

-action "Dwarf" machine has the pedal-levers suspended from links
branches of the fork, and the pedal-levers are themselves connected
curved backward to bring their free extremities properly under the
r travel of the pedals is elliptical, or a mean between the arc of the
complete circle described in the purely rotary machines. The front
backward, so that the curve of gravity is kept well behind the axle of
l, owing to the consequent safe position of the rider, a larger driving-
thout seriously curtailing the safety of the machine. On account of
t, the rider can not use the handle-bar as a rest for his legs in "coasting,"
rdinary wheel. The "Dwarf" machine has usually a pair of foot-rests
the axle on extensions of the fork.
g reached this point in its development, it only remained for the process
luce the present standard form of "Safety" machine, shown in Fig. 4,
use by persons of both sexes, from the child to its grandparent.

FIG. 4.—"Safety" bicycle.

g all the favored appliances of the most approved ordinary roadster, such as cushion
matic tires, ball-bearings, adjustable seats, etc., this machine possesses the elements
and speed to an almost perfect degree.
front wheel is used for steering and the rear wheel for driving, both being of the same
r, viz., usually 30 in., geared to 54 in.
pedal-shaft is carried in the frame just in front of the driving-wheel, its center being
lower than that of the wheel, and an endless chain imparting motion from a sprocket-

wheel upon one end of this pedal-shaft to a wheel of the proper relative size on the driving-wheel axle. The bracing-bars of the frame, all of forged steel, are arranged in different ways —a preferred form of frame in men's bicycles being that of an elongated diamond, the sharper apexes being at the rear axle and front fork, and the other angles occurring at the pedal-shaft and the point where the saddle is supported, a cross-bar lying between the two latter. The front fork is rigid, and made with a curve and "rake" rearward from the front-wheel axle, so that the handle-bar may be within convenient reach of the rider's hands, and the saddle lies just over the front half of the rear or driving wheel.

The Ladies' Bicycle (see Fig. 5) is similar to the above in all respects, save that the backbone of the frame extends downward from the head of the fork close to the rear part of the front wheel, and then curves underneath to a junction with the pedal-axle. Skirt-guards are provided over the moving parts adjacent to the rider's seat. For ladies' use, the present standard diameter of wheel is 28 in., geared to 50¼ in. The brake is of the plunger type in

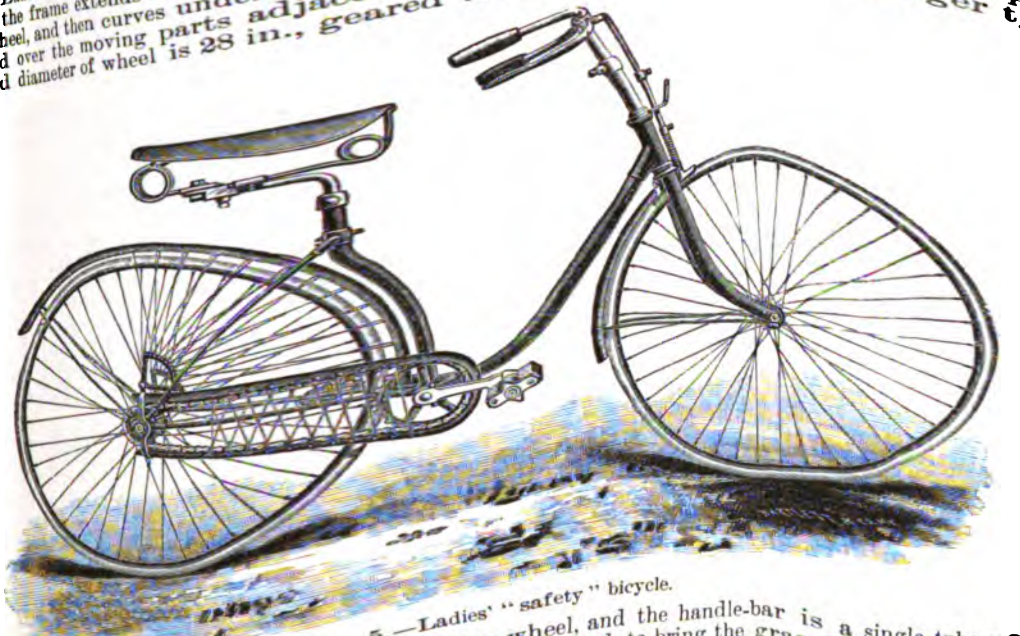


FIG. 5.—Ladies' "safety" bicycle.

both machines, and is applied to the driving-wheel, and the handle-bar is a single tube of seamless steel tapered at each end and curved backward, to bring the grasping pieces, which are of rubber, within easy reach of the rider's hands.

The spokes preferred in these standard "safety" machines are of the double-tangent type.

As a result of continued and practical investigation by experts in this country and England, an efficient anti-vibration device, in addition to the cushioned tires and hubs, has been deemed an essential part of a high-grade modern bicycle; a yielding spring-fork, of which that named the "Victor" is a leading type, has been largely adopted.

It is of especial value for rough-road riding, where obstacles are frequently met with, and great strain consequently brought to bear upon the machine.

The front fork consists of two steel bars "raking" backward from the axle of the front wheel, and pivoted to short links, which are also pivoted to the head, which practically forms part of the frame. Two strong steel springs, bowed toward the rear, extend from the steering-wheel axle, one on either side of the wheel, to a rigid connection with the lower part of the head. The springs carry foot-rests. By referring to Fig. 4, the action of this spring-fork will be understood without further explanation.

The spring-fork is equally applicable to ladies' bicycles.

The Otto Bicycle is the invention of a brother of the inventor of the gas-engine bearing the same name, and probably is the only one of its class, it being believed that no other bicycle exists in which the whole weight of the machine itself, as well as the full weight of the rider, rests upon the driving-wheels.

It is in some respects more nearly allied to a tricycle than to the bicycle proper, but, as it has only two wheels, and consequently requires the balance to be still maintained by the rider, it is rightly called a bicycle. The wheels are of equal size, and are here mounted loose on the same axle, parallel to each other, and both of them are drivers. The rider sits between them, and works a continuous pedal crank-axle, the position of which, when he is seated, is below and slightly in front of the axle carrying the driving-wheels. The crank-axle is connected with the driving-wheels by endless steel bands passing around plain pulleys on the ends of the crank-axle and on each wheel. The bands are kept taut by tightening springs, and the machine is steered by slacking one or other of them, which causes the corresponding driving-wheel to lose motion, and therefore the other wheel overruns it. If a sharp turn has

to be made suddenly, a brake is applied to one wheel at the same time that its driving-band is slackened, which causes the machine to turn round in a circle upon that wheel as the center.

This machine, having no small wheel fore or aft the rider, while steady sidewise, has to balance himself in the direction of his motion, which he is enabled to do through the medium of the pedal crank-axle; by pressing on the forward pedal, if he is falling forward, he throws his weight backward; and by pressing on the rear pedal, if he is falling backward, he throws his weight forward. To prevent him from actually capsizing backward, a safety-tail projects behind upon the ground whenever the seat is tipped too far back. Among the many beautiful features presented by this machine, the best seem to be: Firstly, its balance, whereby the rider is always in the best position to utilize his strength and weight, notwithstanding the varying gradients; secondly, the nicety with which it can be steered; thirdly, its tendency to run in a straight line without any effort on the part of the rider; fourthly, its freedom from vibration; fifthly, the circumstance that it makes only two tracks; and, sixthly, the perfect distribution of the wheel-load.

The power required to propel a bicycle on an average road has been approximately estimated at from $\frac{1}{4}$ to $\frac{1}{8}$ of a horse-power, according as the speed varied between 6 and 14 miles per hour, with the odds in favor of a rotary-action against a lever-action machine.

Tandem Bicycles.—One of the earlier machines of this class is constructed of two ordinary bicycle driving-wheels complete in their forks, which latter are connected by a backbone, having in its length a swivel or axial joint. Each rider drives his own wheel, sitting just behind its center, and each steers independently of the other for balancing himself. The axial joint in the backbone, and the joints formed by the heads of the forks and the bearings of the wheels, together make a perfect universal joint between the two wheels. Within certain limits the rear rider has of course to follow in the track of the front wheel; otherwise the heads of the two forks become locked, and a dismount is rendered necessary. Although this machine is very fast, lighter than two ordinary bicycles, and almost entirely free from vibration, there is an element of danger about it that militates against its general use, inasmuch as it demands to a certain extent a unity of thought and action on the part of the two riders.

The Tricycle, as its name implies, is a three-wheeled machine, each one of which wheels must be free to move in its own direction, independent of the united action of the other two. For running in a straight line, all three wheels must be parallel; while for running round a curve, one or more of the wheels must be turned uutil the center lines of the axles intersect in plan, their point of intersection being the center of the curve round which the machine will then run; therefore, the more acute the angle of intersection, the greater will be the radius of the curve; and, inversely, the more obtuse the angle, the sharper will be the curve. Besides being independent in the direction of running, each wheel must also be capable of revolving at a greater or less speed than the others. It is also essential that the greater part of the rider's weight shall be on the driving wheel or wheels, and that only enough shall be on the steering wheels or wheel for insuring their proper action. Owing to the variety of ways in which these principles can be carried out practically, it is easy to account for the variety of tricycles constructed.

The simplest form of tricycle is obviously that with only one driving-wheel, either or both of the others being used for steering. An early type of single driver, now practically obsolete, had two large wheels mounted opposite and parallel to each other, one of which was driven, and the other was allowed to run free; the third, or steering wheel was placed centrally in the rear.

Another form of single driver has the large driving-wheel on one side, and two small steering-wheels on the opposite side, placed respectively fore and aft of the driver, and arranged to turn together, bnt in contrary directions. The double steering, fore and aft, of the driving-wheel overcomes the tendency of the machine to run in a curve, in consequence of the single driving-wheel on one side. This was one of the first tricycles introduced, and has stood the test of competition, being at the present time one of the most popular. Its chief features are that it is simple in construction, makes only two tracks when running, and is narrow in width. Its narrowness, although rendering it somewhat unstable in running round a curve at a high speed, allows of its passing through a doorway of ordinary width.

The third and last kind of single driver has the driving-wheel placed centrally in the rear of two steering-wheels, which are mounted parallel and opposite to each other. The defect of this arrangement is that the weight of the rider is too equally distributed over the three wheels, instead of coming more upon the driver than upon the other two.

There are several types of double-driving tricycles, where the two driving-wheels are placed parallel and opposite to each other, with the steering-wheel in front or behind, and generally central, though in some cases it is placed in line with one of the driving-wheels, so that the machine then only makes two tracks.

The two principal methods of double-driving are: first, by clutch-action; and, secondly, by differential or balance-gear.

In the clutch-action plan the two driving-wheels, or the chain-wheels driving them, are locked to their axle while the tricycle is being driven straight forward, but in running round a curve the outer wheel overruns the clutch, and the inner wheel alone drives. Of the various clutches so far devised, probably the best results have been attained by that known as the Bourdon clutch. It consists of a disk fixed upon the crank-axle, and having its circumference cut away so as to form a series of inclined planes. A box forming the boss of the chain-wheel encircles this disk, and in the recesses of the inclined planes which join between the disk and the

box, and so lock them together as long as the axle is driving the wheel. Whenever the wheel has freed itself by overrunning the axle; there will always be at least one of the rollers ready (in every position) to instantaneously lock the two together again as soon as the speed of the wheel falls back to that of the axle. The pedals can remain stationary whenever the gradient of the road will allow the machine to run of itself, an advantage which economizes the expenditure of power, as the feet of the rider can remain motionless for the time being. The brake, however, must be entirely relied on for checking the speed, as it can not be stopped by back-pedaling. A clutch-driven machine can not be driven backward without some extra gearing. Many attempts have been made to construct a clutch that will drive automatically in both directions, but the writer is not aware that any have proved successful, the reason of their failure being that they were not instantaneous in action.

The mode of double-driving by differential or balance gear—so called because the power is divided or "balanced" between the two driving-wheels—employs an epicyclic train in which the two primary wheels are each connected directly or indirectly with one of the driving-wheels of the tricycle, and also connected with each other through an intermediate loose train. One of the simplest forms of differential gear somewhat resembles an ordinary reversing train; one of the two facing-wheels is fixed to the hub of one of the driving-wheels, which runs loose on the axle, and the other facing-wheel is fixed on the driving-axle, on the hub of which is fixed the other driving-wheel. Between the two facing-wheels a chain-wheel is mounted loosely on the axle, and this carries loose on a radial axis a bevel pinion-gearing permanently with both facing-wheels.

When the tricycle is running in a straight line, both driving-wheels are driven equally by the chain-wheels, the two facing-wheels meanwhile being drawn round by the intermediate pinion, which at that time is idle.

But when the tricyle travels in a curve, the inner driving-wheel revolves at a slower rate than the outer wheel, and consequently the outer driving-wheel is driven through the bevel-gear at a consequently higher speed, in whichever direction the machine is running, whether forward or backward.

As already described in regard to bicycles, there are two methods of driving a tricycle: Firstly, by rotary action, in which the power is applied either directly to a cranked axle carrying the driving-wheels, or to a cranked pedal-axle connected with the driving-wheel axle through an endless chain or other means; and, secondly, by lever-action, where the power is applied by reciprocating pedal-levers, from which the motion is communicated to the driving-wheel axle through cranks and coupling-rods, or otherwise. The lever-action lends itself most aptly to obtain varying power; but in speed the rotary action is superior. The reason would seem to be that in the lever-action the direction of force is changed so suddenly that in rapid pedaling a certain amount of back pressure is unavoidable.

Of direct-action or rotary tricycles, the simplest form has two driving-wheels mounted on the end of a cranked axle, and connected to it by clutches, the rider driving the axle direct. This arrangement simplifies the construction and reduces the working parts; but the high position of the center of gravity offers an objection to the stability of the machine.

The swinging pedals are sometimes hung from the cranked axle, thus lowering the center of gravity, and rendering the machine more stable.

A successful lever-action machine is called the "Omnicycle," which is fitted with a variable-power gear.

The pedal levers are connected by bands to two expanding segments connected by clutches to the driving-axle, and to each other by a reversing apparatus, so that the forward movement of the one produces the backward movement of the other, thus the descending pedal raises the other ready for the next stroke.

The frames of tricycles are largely constructed of weldless steel tube, and their contour and general arrangement vary with the different types of machine. Malleable-iron castings have been used in many of the solid parts.

The steering-gear of such tricycles as have a single steering-wheel is usually the same as that of a bicycle, employing a transverse handle-bar; but another method, using a rack and pinion, is frequently adopted. The pinion is fixed to a vertical handle, mounted in bearings, so that it can revolve; and the rack forms part of a light rod, the free end of which is connected with an arm fixed on the fork of the steering-wheel.

In each different make of tricycle there is a certain position for the rider's seat, in respect both to the axle of the driving-wheel and also to the pedal crank-axle, so as to permit the rider to exert his power to the best advantage. The best position for the seat on a front-steering tricycle is generally 1¼ in. in front of the driving-axle, and 7 in. behind the pedal-axle, this axle, therefore, being 8¼ in. in front of the driving-axle.

The above-described tricycles are types of those manufactured and used in England, where such machines find much more favor than in the United States.

The only form of tricycle which has been extensively made and sold in this country is shown in Fig. 6. It is called the "Surprise Columbia Tricycle," and has a 32-in. rear driving-wheel, operated from the pedals by sprocket-wheels and a connecting chain.

There are two 26-in. front steering-wheels, journaled on the ends of a cross-bar or axle, forming part of the frame, adapted to be adjusted so as to vary the width of the running-track as well as to be folded, to still further reduce the width, in order to enable the machine to pass through ordinary doorways. The width is variable, between 34 in. and 29 in. all over.

The wheels, crank-shaft, and pedals are fitted with adjustable ball-bearings, and the wheels

mented into the felloes, and direct spokes headed at the felloe and screwed l hub-flanges.

ever-arm at the bottom of each steering-head is connected by a high rod to a lever pivoted below the main-frame bracket, and taking its motion through a connecting-rod attached to the lower end of the handle-bar upright. The brake is similar to that of a bicycle.

3. 6.—Tricycle.

Hand-Power Tricycles have been introduced from time to time, notably the Oarsman and Velociman. In both of these driving-power is exerted by the arms instead of the legs. Their use, however, is very limited, being only of service in particular instances.

Sociable Tricycles.—This type is merely an enlargement of the single form of tricycle, so as to permit two riders to sit side by side. Some "Sociables" are capable of being converted into single machines.

Tandem Tricycles are constructed so that the riders sit one behind the other. The tandem ied to most of the principal forms of tricycle, notably to those differentially nt-steering type, by using an auxiliary trailing-frame with transverse and etween it and the front frame: and to the rotary machine by the addition of ced in the rear of the front seat, to carry the hind seat and pedal crank-axle r. Tandems of several classes are made convertible into single machines.

cycles.—The last kind of tricycles is one capable of being put to practical use ourden. There is one form known in England as the "Coventry Chair," where carried in a comfortable chair constructed in the front part of the machine, and t and driving mechanism, similar to that of the ordinary tricycle, are located iving-wheels in rear.

g Art, Energy and Locomotion, by R. P. Scott; and *Construction of Modern* E. Phillips.)

egulator: see Regulators.

see Crane.

Drill: see Drills, Rock and Quarrying Machinery.

Brick-Making Machinery, Milling Machines and Pipe Cutting and Threading

ERS, LIME SULPHITE FIBER. Sulphite fiber, or pure wood cellulose, su stock in paper-making. The wood in chips or disks is boiled in great digesters on of bisulphite of lime, and the main engineering problem lies in the construc able, economical, and lasting digester.

wing notes on digesters are condensed from a valuable paper on Lime Sulphite facture in the United States, by Major O. E. Michaelis, U. S. A. (see *Scientific upplement*, No. 732, 1890): Exteriorly all the digesters are of metal, all of open or iron plate, except the Schenk, which is of so-called deoxidized bronze. All nately cylindrical, except the Partington, which is spherical. The cylinders are the Ritter-Kellner and Schenk processes; in the Mitscherlich and Graham they al. The digesters are fixed, with the exception of the Partington and Graham, ive, the Graham about its longer axis. Considered merely as a vessel strong stand a given pressure, the only available substance of which the digester can be ng from an economical standpoint, is iron or steel. The majority of the digesters rolled iron plates; the Detroit, of open-hearth steel. There is no reason why our ith a tensile strength approximating 40,000 lbs., should not be available for digest could be turned out in sections ready for assembling; the advantages of such a for the complicated rivet-work shell are evident. At remote inland points the ters must be assembled *in situ*, and boiler-makers must now be transported for the A properly handled wrench would suffice to set up the sectional cast-iron construc 4 × 40 ft. cast-iron digester has been designed, with a factor of safety of 6, which ess than the riveted apparatus, to say nothing of the facility with which it can be d and the ease with which it can be assembled by unskilled labor. We come now de of the digester. Owing to the well-known affinity of the bisulphite solution for igesters made of this metal must be lined with a resistant, fluid-tight material, as a against the solvent action of the "acid" mixture. The Schenk digester, a uni struction of deoxidized bronze, is assumed to be sufficiently resistent to the solution rotecting lining. The Graham, Partington, and Ritter-Kellner digesters are all the Mitscherlich fire-brick lined. The bricks used are of special form, made of refractory clay the same as used in the manufacture of the Nassau Seltzer jugs.

r Linings.—The vital point in these sulphite processes lies in the ability of the resist the erosive action of the acid solution and its gaseous products. Lead has es been used as a lining material in the manufacture of sulphuric acid, so that its to the present sulphite fiber processes lay near at hand. It is used in the Graham, and Ritter-Kellner digesters. In speaking of the sulphite process the *Encyclo tannica* uses the following language: "The pulp or fiber produced by all these

processes is of excellent quality, and can be prepared at a cost greatly lower than the soda process. The strength of the fiber is maintained unimpaired even after bleaching, and white paper made solely from such fiber is in every respect superior to that manufactured solely from pulp prepared by boiling with caustic soda. Dr. Mitscherlich's process has been extensively adopted in Germany, and there seems little doubt that these processes will in time supplant the use of soda in the case of wood. The great objection to them all is that, as they all depend on the use of bisulphite, which, being an acid salt, can not be worked in an iron boiler, the boiler must be lined with lead, and great difficulty has been encountered in keeping the lead lining of the boiler in repair."

The primary, indispensable condition in protecting iron sulphite boilers with lead is that the lining must be continuous—that is, liquid-tight. Now, lead has a linear coefficient of expansion much more than double that of iron; in these processes it is subject to a change of temperature of at least 240° F. (300°–60°), and the unavoidable resulting flow of the metal can not be compensated for by permitting sections to expand and to contract freely upon each other, for that would require open joints, a violation of our primary condition. The lead lining must in some way be attached to the iron shell, for otherwise it would soon collapse, or go to pieces in some other way. Only three practical ways offer themselves for the attachment of the lead lining to the iron. It may be bolted on at proper points; it may be, to borrow a plumber's phrase, "tacked on" at appropriate places, or it may be completely soldered on. The first two methods permit, as is evident, under variations of temperature, changes in the superficial area of the lining; the latter method forcibly resists this, and limits the flow of the lead during the life of the solder union to molecular expansion only.

The Partington Boiler is spherical; the lead is applied in spherical lunes, clamped to the iron, and burned to each other. The theory is, that it is an easy matter to replace an injured section, and thus to keep the lining intact at comparatively little cost.

The Ritter-Kellner Digester, about 10 × 28 ft., is built up of cylindrical sections, 4 ft. wide, a few inches apart, and fastened by heavy exterior bands. The object of this construction is to provide the means for attaching the lead lining peculiar to this process. The spaces between these sections form annular dovetail mortises, which are filled with an alloy of lead and antimony, and at the ends of a diameter meet similar vertical tenons, to which they are attached. The lining is burned fast to this semi-cylindrical frame. Here, again, under the irresistible force of expansion, these great sheets of lead, roughly speaking 16 × 4 ft., must theoretically, if the tacking holds, "pucker up," and again be forced back against the shell under contraction and pressure.

The Graham Digester, 7½ × 22 ft., is made of sheets of boiler-plate, to which the lead lining is soldered before bending and assembling. The method of doing this is ingenious and simple. The sheet is cleansed and smoothed by a radially traveling emery-wheel; it is then firmly fixed for half its surface over a gas-jet heater. The rectangular frame that holds it down is packed with fire-proof packing where it rests upon the plate, thus actually forming a water-tight vessel, of which the iron to be leaded is the bottom. The plate is copiously doused with a solution of chloride of zinc, and, when heated to the proper degree, molten lead in sufficient quantity is poured upon it. Although the promoters of this process do not so call it, it is, nevertheless, soldering, which is authoritatively defined to be "the process of uniting two pieces of the same or of different metals by the interposition of a metal or alloy, which, by fusion, combines with each."

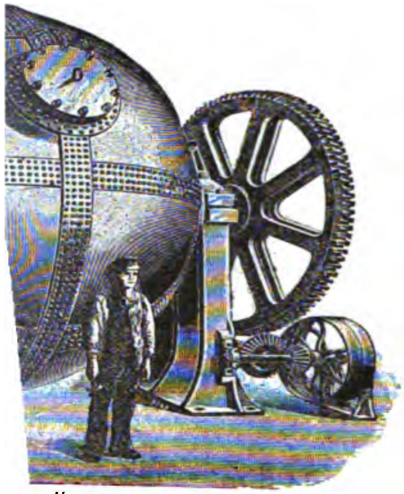
Brick-Lining.—The Mitscherlich Digester is lined with an acid-proof brick of special design, laid in Portland cement. Apparently a startling innovation, reflection proves that this method follows out the direct line of modern progress. The manufacture of that almost indispensable article, sulphuric acid, has in comparatively late years been greatly improved and facilitated by the introduction of the Gay-Lussac and Glover towers, edifices lined, not with lead, but with acid-proof tiles or brick.

Unlined Digesters.—The Schenk Digester is a stationary, upright cylinder, 7 ft. in diameter by 22 ft. height, and is made in sectional castings of deoxidized bronze, with planed flanges, which are bolted together and lead-jointed in assembling. This alloy the designer assumes is sufficiently acid-proof for the purpose, without the protection of other resistant lining. It is acknowledged that the deoxidized bronze is acted upon by the acid solution, and observation confirms this conclusion; but it is claimed that this erosion is so slight that the longevity of the digester is not threatened thereby.

Acid Process.—The manufacture of the bisulphite solution may be classified under three heads: the vacuum process, the modified tower process, the tower process. The vacuum system is used in connection with the Partington, the Schenk, and the Graham processes. It requires large exhaust-pumps, a series of tanks arranged vertically in echelon, a lime-mixer, etc., and undoubtedly yields with certainty the high solution required. It can be used for all the processes. The modified tower system, in use with the Ritter-Kellner process at Cornwall, is a sort of cross between the Mitscherlich tower and vacuum method. The solution is pumped by a battery of pumps into a series of low towers under cover, filled with limestone. The Mitscherlich tower process is in a measure automatic, and is certainly the most economical. The sulphurous-acid gas is drawn up the high towers, filled with limestone, by atmospheric draft, and therein meets water trickling through the filling. Its main disadvantage is the assurance of proper draft. The consumption of sulphur varies from 200 lbs. per ton of fiber in the Mitscherlich up to nearly 600 lbs. in the others. In none of the others is it less than 350 to 400 lbs.

Mechanical Preparation of the Wood.—All the processes, except the Mitscherlich, use

; from the log, 1¼ in. deep, are used. Dr. Mitscherlich ger fiber, and that more bulk can be put into the digester than if loosely piled chips were used.

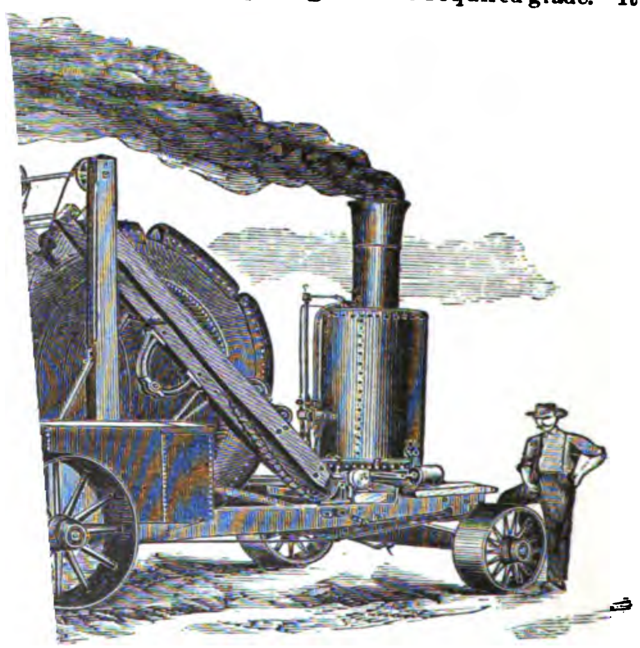


ır digestor.

A recent form of digester of English manufacture is represented in Fig. 1. It is made of Siemens-Martin mild steel plates, $\frac{11}{16}$ in. thick and 12 ft. in diameter inside. The rivet-holes on the inside are countersunk, to present a level surface to the lead lining, which is patented. The lining is made in large sheets, and is held against the steel shell by means of a series of clamps fastened from the outside. The digester is filled through the man-hole, which is 2 ft. in diameter, from a high level, with timber and sulphite liquor, and through the trunnions, while the digester is slowly re-n gearing, as shown in the engraving.

Machinery.

d for excavating ditches and trenches for drainage, etc. e whole ditch in one passage on the required grade. It

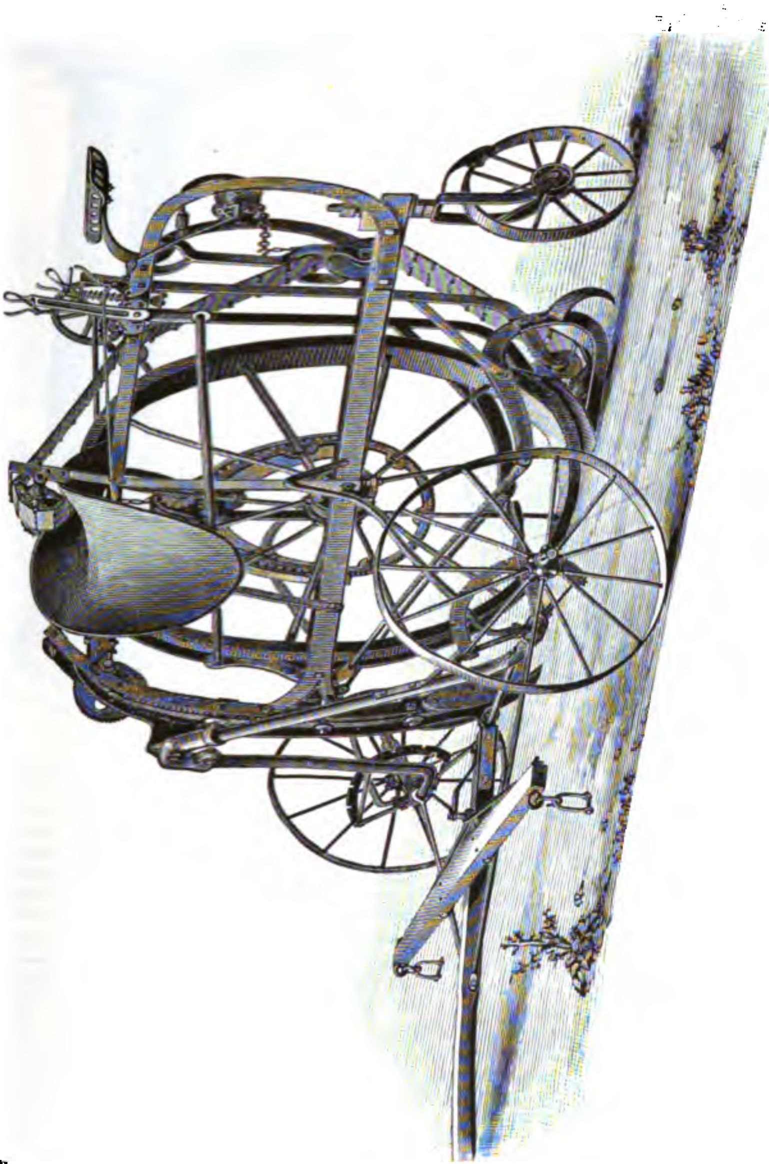


ıe Plumb Ditcher.

ırge cutting-wheel, all set in one frame carried on drawn forward when working by means of a wire ıy distance ahead and winding on a drum on the g wheel is formed with rim-scoops, which cut and :he ditch upward. The cutting-wheel hangs in a

swinging frame raised or lowered at will to maintain the grade line r of the ditch, and can cut to a depth of 4 ft. It forms a rounded botto for the reception of either of the ordinary sizes of farm drain-tile. Th at one side of the ditch, convenient for refilling. As the wheels are 10 works on soft ground as well as hard, even where horses could not be e

Potter's Ditcher (Fig. 2) is drawn by animals, and, being a compa performs its work by passing repeatedly over the same job until the



required depth. The cutting-wheel cuts down the sides of the ditch, a the lowest part of the wheel pares off a layer of dirt, and causes it to control of an endless apron, which retains the earth in the grooved until the dirt is discharged upon a spout at the top and dumped on The digging can be interrupted to maintain the grade of the ditch. wheel frame is pivoted above its center of gravity, and maintains an u a perpendicular ditch at all times, whether the ground is level or inclin stones are readily thrown out, but large ones the machine rejects ar them bare of dirt, so that they may be reached and removed by other

Doffing: see Cotton-Spinning Machinery.

Dog: see Saws, Wood.

app dovetailing-machine (Fig. 1) the work done
ring-pins engaging any mortises of similar out-

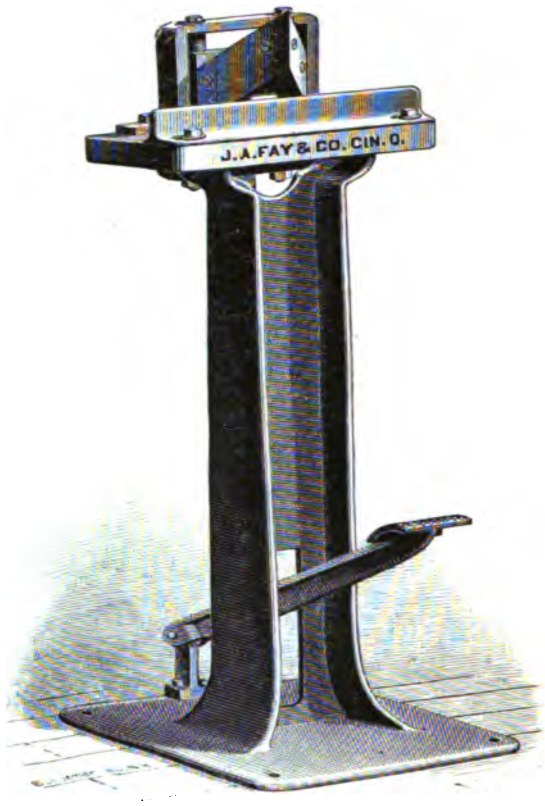


FIG. 1.—Dovetailing-machine.

‹ for repairs of machinery, and all days regarded
tions of the chain of buckets and links are reduced
al not tenacious, allowing buckets to revolve 25 to
: construction have done satisfactory work, and are
hose of wooden structure, and much more stiff.
ng steamed out from Scotland to Colon and also to
boilers are of 200 horse-power, and their horizontal
aft on which is a sprocket-wheel, The upper tum-
ı endless chain communicates from the lower to the
heavy work these teeth break at frequent intervals.
e construction of parts to gain the required strength
night be lighter and require less power to raise and
deep-sea work than attacking new banks. It dis-
fore-and-aft guys and side-guys wound on friction-
. 6 tons of coal per 12 working hours. In ordinary
00 cubic metres per day of 12 hours.
ncipal dredge in use along the line of the Panama
most in use being 100 ft. long by 30 ft. broad, and
ulls and entire machine are constructed of iron, in
transhipped at different points along the line where
cimately, $115,000 at Colon, not including cost of
k at Panama, some engineers estimating the cost of
:. The tower is quite low, the elevation of hopper
ove water-level. The ladder is in one section, sup-
length to the use of dredge in attacking new banks
ıre of iron, wrought in one piece, the links being an
n a vertical engine, having three pistons, which act
has a gear-wheel at either end, and large balance-

wheels. These gear-wheels connect through two other gear-wheels to the upper tumbler-shaft, thus giving a positive power, and when the machine is dredging in rock no slipping occurs, as in a belt connection. The engines are 180 horse-power in this sized dredge, and it forms a most powerful machine, so that in attacking hard-pan or loose rock it receives such a force as to accomplish its work when buckets and links do not break. In ordinary work in sand, gravel, clay, and loose material, a positive force is not necessary, as in rock-work. The large belt from a horizontal engine connecting with a gear attachment fitted with a tightener-pulley, increasing or diminishing the tension, has given good satisfaction, and controls the movements, except in rock-work.

The dimensions of a French dredge of large type are as follows: Length, 120 ft.; breadth, 28 ft.; depth, 10 ft.; draft, 7 ft.; depth of working, 28 ft.; sheer fore and aft, 10 in.; rise of deck, 6 in.; height of discharge above water-line, 20 ft.; height of top tumbler above water-line, 26 ft. 6 in.; width of bucket-well, 5 ft. 3 in.; frames, $4 \times 3 \times \frac{3}{8}$ in., 2 ft. apart, with reverse angle-irons $3 \times 3 \times \frac{3}{8}$ in., in alternate frames; plating of bottom and bilges, near well, $\frac{7}{16}$ in.; plating otherwise, $\frac{3}{8}$ in.; plating of sides, $6\frac{3}{8}$ in.; plating of well, $\frac{3}{8}$ in.; deck-beams, bulb-iron, $8 \times \frac{3}{8}$ in., with double angle-irons $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$ in.; floors, 12×4 in.; angle-irons, $3 \times 3 \times \frac{3}{8}$ in.; length of bucket-ladder between centers, 64 ft. 6 in.; capacity of buckets, 16 cub. ft.; diameter of pins, $2\frac{7}{8}$ in.; high-pressure cylinders, 17 in. diameter by 24-in. stroke; low-pressure cylinders, 34 in. diameter by 24-in. stroke; air-pump, 10 in. diameter by 15-in. stroke; circulating pump, 10 in. diameter by 15-in. stroke; boiler diameter, 10 ft. 6 in.; boiler length, 9 ft. 6 in.; boiler heating-surface, 900 sq. ft.; boiler working-pressure, 80 lbs. per sq. in.; cost at Colon, $115,000.

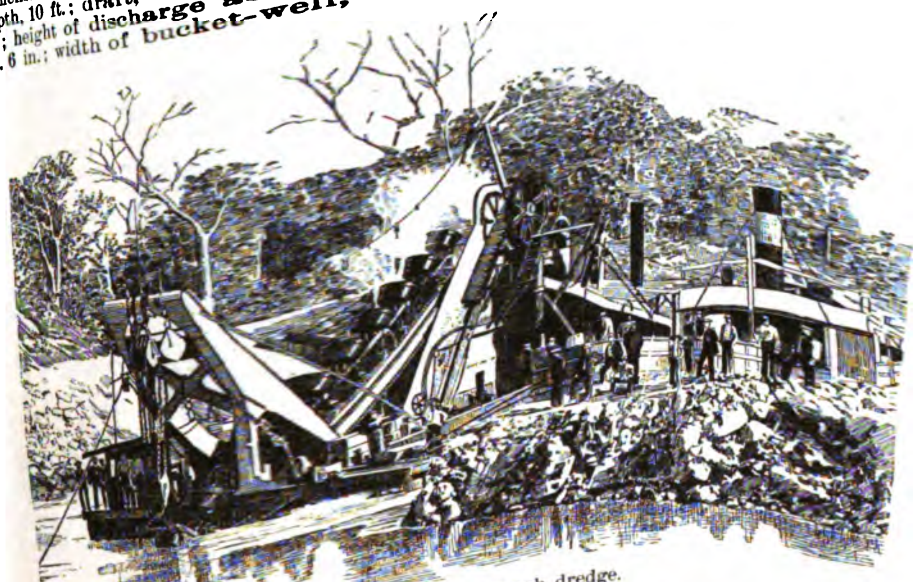


FIG. 1.—The French dredge.

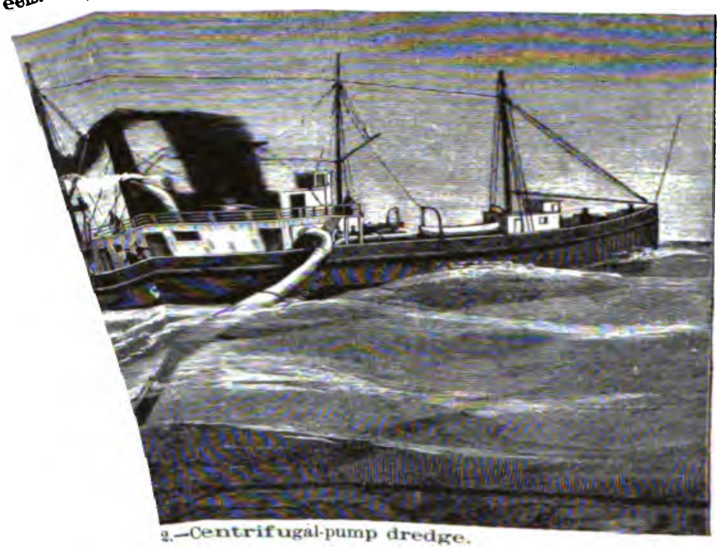
One of these machines of large type has done valuable work at the Mindi Cut, near Gatun, on the Panama Canal, in broken rock, stiff clay, and hard-pan. The material excavated in buckets is carried up into a hopper, discharged with water, pumped up hydraulically sufficiently to discharge it into self-dumping steam-clapets alongside. The capacity of these dredges is variable in the extreme, no one machine having done a large amount of satisfactory work. A fair estimate is 200 to 250 yards per hour for 12 working hours.

The Belgian dredge is quite similar to the French dredge, deriving its power in like manner by sprocket and chain connection. It is of 200 horse-power, has three horizontal return tubular boilers, and two horizontal engines, the pistons of which connect with a crank-shaft, on which is a wheel. It discharges on each side into clapets. The velocity of the buckets is 20 to 30 per minute; contents, $\frac{1}{3}$ cubic metre.

Dredging Operations in New York Harbor have been actively carried on in order to improve the channels leading from the ocean. The fleet of vessels employed by the contractors comprises three propellers, each fitted with two Edwards centrifugal pumps and two dredging-scoops connected by pipes with the pumps. Each vessel (Fig. 2) is divided by bulkheads into tanks for the reception of the dredged material. In the bottom of each of the tanks are valves, worked by horizontal valve-wheels. By proper conduits the dredged material can be delivered to any one of the tanks, according to the way in which the chutes are set.

The estimated capacity of the plants per working-day are: No. 1, 2,000 cub. yds.; No. 2, 1,500 cub. yds.; No. 3, 3,000 cub. yds.; giving a total capacity of 6,500 cub. yds. All the material is taken outside of Scotland Lightship and dumped at a distance of about 8 miles from the

d 5 miles from Gedney's Channel, in not less than 14 fathoms of
on is as follows: The scoop (Fig. 3) is dropped down to the bottom, on
eels. The pipe which connects it to its pump is of steel, containing a ball-and-socket joint, and including a short length of heavy India-rubber pipe re-enforced with steel bands, in order to prevent breakage when the vessel is rolling or pitching in a sea-way. By means of a steam-jet connected with the top of the centrifugal pump, a vacuum is produced within the pump and pipe, under the effects of which vacuum water rises through the pipes until the pump-chamber is completely filled. Then, on starting the pump and opening the outlet-valve hitherto closed, it at once begins to draw up material. At the upper surface of the scoop, a foot or so above the water-valve is arranged which may be opened or closed by means of a



2.—Centrifugal-pump dredge.

This is done from the deck of the propeller, and regulates the pro-
solid material. The operative can tell by the sound of the pump
oo much or too little solid material, and sets the valve accordingly.
is made to advance at the
an hour, while both pumps
be. It is very important
ll capacity, as they possess
ich their efficiency is great-
ius travels down the chan-
scoops, which are continu-
nd, which, as fast as it is
through the pipes by the
re attached to the side of
o that they are unaffected
to the great width of the
it that they are not there-

The Kobnitz Rock-Break-
tes by letting fall a heavy,
the surface of the rock,
illery-fire demolishes the

sented in the engraving
k in the enlargement of
ull of this rock-cutting

Fig. 3.—Dredge-scoop.

n draft is 9 ft., and there dredger is 180 ft. long by 40 ft. broad
rams, each weighing 4 tons, are 18 water-tight compartments. Five
ch the buckets lift the crushed arranged in line on each side of the
0 ft., and they are then let fall rock. Hydraulic power raises them
tumbler, or they can be moved on the rock. These rams can work
f the dredging-gear or the requirements by steam-power, either forward or
l below the steam-crane, between 200 of the work. With the set
et of five cutters. Combined and 300 blows per hour can
cially adapted for lifting with the rock-cutting apparatus,
orts the sag of the bucket-chain broken rock, is provided. A guide-
earings and pins. With this when wear has taken place, and re-
of the machine is 40 ft.; without guide-wheel or relieving-drum, the
t-chain there is a four-cylinder it more than 30 ft. would not be
ich by special friction-gear works two-crank compound engine of 200
two steel pitch-chains passing

arried on upon the pneumatic foundations of the Morand
dger of this system is employed, it dredged in 38 ft. of
diameter and weighing 110 lbs., the height it was raised
apparatus, which is 10 in. in diameter, is actuated by a
b. in. of air per sec., and is situated at 150 yds. from the
The forcing apparatus, which is a cylindrical reservoir
with convex ends, and having a capacity of 176 cub. ft.,
material. The air escapes through an opening above sur-
side of which there is a waste-pipe. When the reservoir
escape through the waste-pipe, a single external lever,
closes valves that in turn close internally the orifice of
ir-port, and at the same time reverse, through three-way
which is then forced through distinct pipes into the reser-
properly spaced, in the lower part of the reservoir. The
formed under the mass of earth and water, is to lift the
and throwing it toward the orifice situated at the lowest
time taken to force to a distance of 1,000 ft. is 6 min., 2
sage through the conduit. The end of the tubing is worked
conduit, of a wheat-sheaf jet of water and air projected
the orifice, the conduit remaining empty and being cleaned
At the same time, the automatic valve that closes the
by its own weight. The lever that works the cocks is then
the dredging-pipe, and another filling at once occurs. Thus
uccessively by periods of from 5 to 6 min., the boat remaining
riod.

lge consists essentially of a dredging-pipe which lifts the ma-
rates a shaft armed with knives. The pipe is connected with
the material into floating pipes.

16 in. in diameter, is arranged in a well 35 ft. in length, and
redger. It is connected with the conduit that leads to the
conduit is provided with an aperture through which a work-
stopping the pump, extract too large pieces of excavated
mage the pump-buckets. At its other extremity the pipe is
s a frame cast in a piece with it, and in which are arranged
As the pipe has to dredge at variable depths, it is capable of
e-frame established on the two sides of the well, and the wind-
ctly by a small motor. In order to secure the rigidity neces-
is guided by a frame which consists of uprights connected
s in a slide placed between the uprights of the double frame.
ing, the pipe and frame are raised. In order to regulate the
, the latter is provided with three slide-valves, each sliding
g rectangular orifices. These valves are actuated by hand
pipe, and which, through a screw-thread, actuates the nuts

has to be modified according to the ground operated upon.
lay, a shaft armed with a double set of knives is used. These
knives, which are solidly keyed to a box, are helicoidal in
form, and the spirals run in opposite directions, so as to
bring the material that they detach toward the orifice of
the pipe. In compact earth, where no caving in is to be
feared, the knife-shaft is arranged at the extremity of
the pipe. In muddy sand, it is well to establish the
shaft at a certain distance behind the orifice. The
knife-shaft receives its motion, through bevel-wheels,
from another shaft parallel with the axis of the dredge-
pipe, and resting upon it through the intermedium of
pillow-blocks. This shaft is actuated by the principal
motor through bevel-wheels. The centrifugal pump is
placed above the float water-line. The result of this ar-
rangement is that the power necessary for suction de-
pends in practice only upon the difference in density be-
tween the surrounding water and the column of liquid
charged with earth, which rises in the pipe, thus permit-
ting of dredging to variable depths without sensible in-
crease of motive power. The excavated matter passes
through the pump and is forced into the floating pipes.
These are of iron plate, with flexible joints. The engine
is of 120 horse-power.

The Morgan Grab-Dredger Bucket, represented in
Fig. 5, is employed in the dredging of the Mersey dock
at Liverpool in all dipper-dredgers. It is worked by two
of the crane. The lifting-chain is shackled to a large cam-
n a sleeve, which turns loosely on a shaft passing along the

…LLING-MACHINES, METAL.

of these large type of machines is about 30 tons. Self-propulsion connection with the main engine-shaft to the rear axles. Water- ed on the rear car near the boiler. These machines will excavate and dump contents of dipper 29 ft. above track. The mode of to start at the face of the cut and gradually excavate forward and width for the placing of two tracks, one on each side of the excava- rd in reaches of 8 ft., each digging her own track. Dump-cars are either track from the rear switches by cable connection winding erior of the body of the excavator. These cars when filled are hauled nd empty cars are in readiness to supply their places. The dipper then on the other, the cars being constantly supplied. In sand and 2,000 yds. per day of ten hours have been excavated.

NES, METAL. *Universal Radial Drill.*—Fig. 1 represents a uni- y the Niles Tool Works, Hamilton, Ohio. A heavy, rotating column, upporting sleeve, which is secured to the base-plate, carries a radial pped in any position. The machine is driven from an overhead coun- vel-gearing, and by a central spur-gear seen at the top of the column. s motion through tumbler-gearing to the screw, which is operated to m by power. Motion is communicated to the drill-spindle from the back-geared by means of spur-gears, a splined shaft, and bevel-gear-

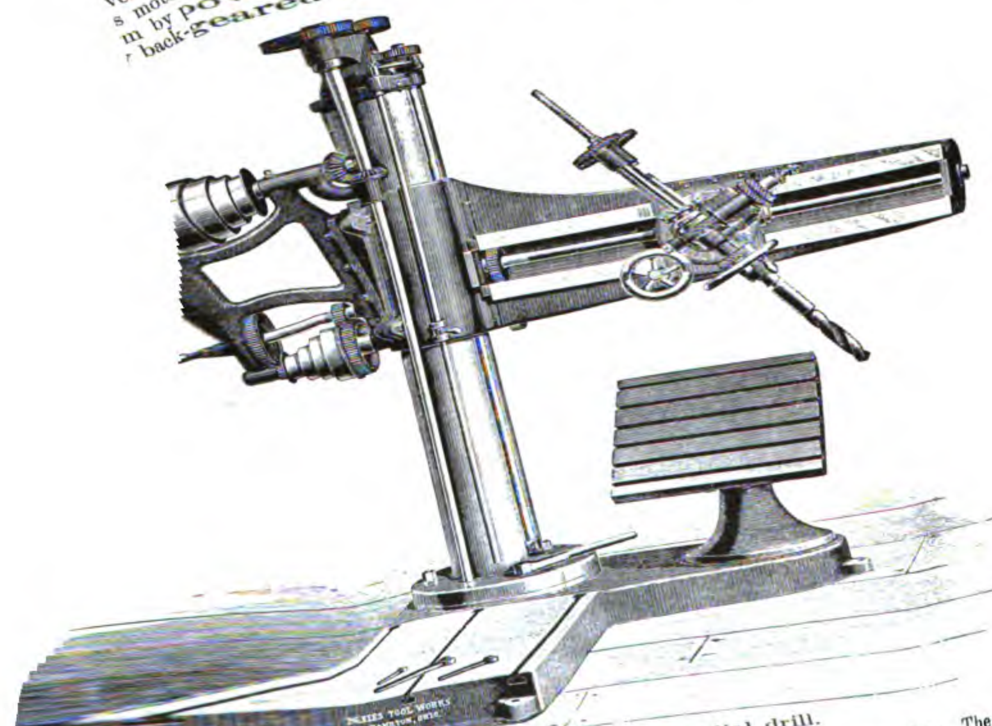


FIG. 1.—Universal radial drill.

rm is in form similar to a box-girder, and is in one piece. The drill-head is se- d upon the arm, and is adjustable to any position thereon. It is also adjustable lar position upon its saddle.

e *Drill.*—Fig. 2 represents a sensitive drill manufactured by W. F. & J. Barnes, ll. by the friction-disk, shown in the cut, the speed of the drill-spindle can be r diminished, or the motion reversed, without stopping the machine or shifting e feed-lever is provided with a sensitive adjustment, which makes it possible to use st drills. The platen can be moved on the column, and clamped at any desired

ple Traverse Table-Drill.—This machine, shown in Fig. 3, is built by the Niles Tool d is similar in design to the usual pattern of multiple drill, except that it is pro- a table arranged to slide upon the bed. Machines of this class are especially de- en it is required to drill a number of holes in heavy pieces clamped together, such

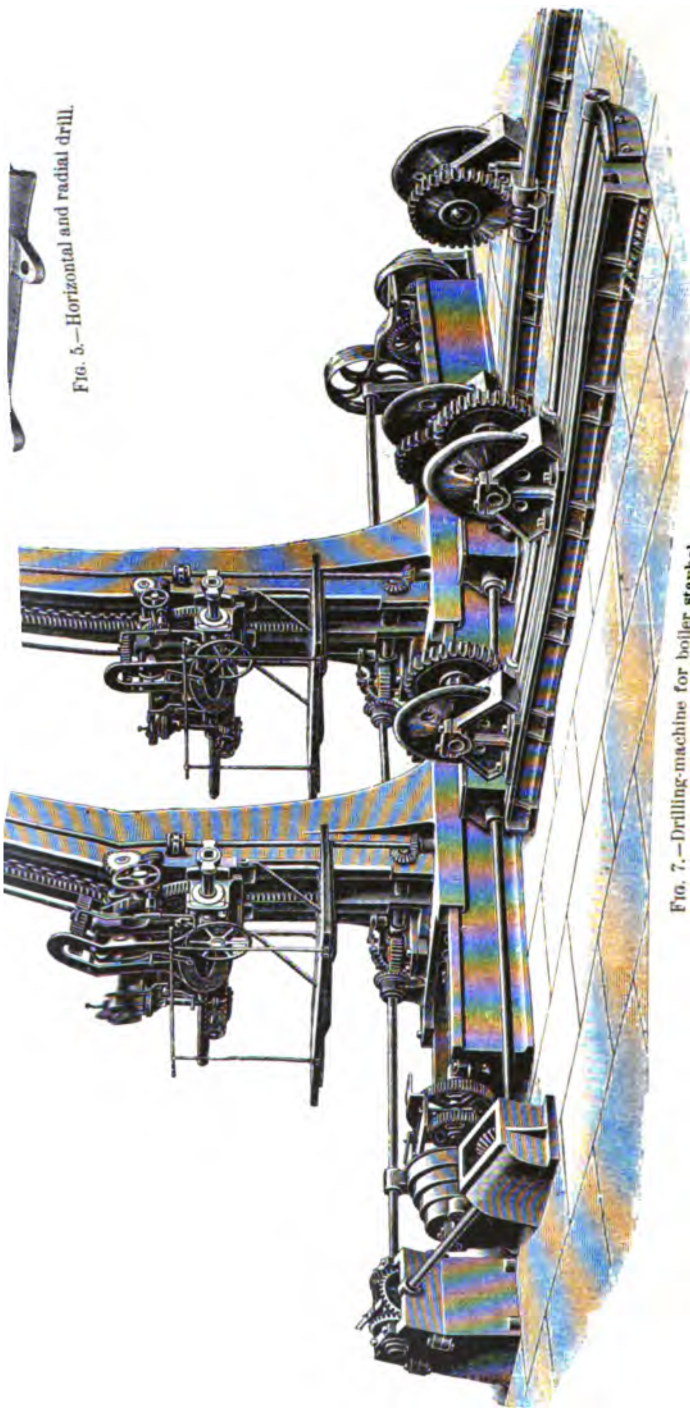


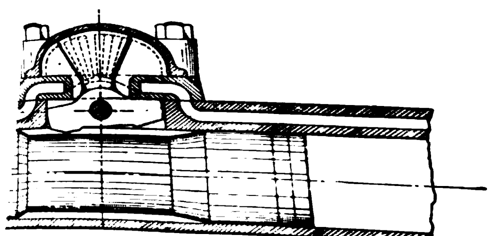
Fig. 5.—Horizontal and radial drill.

Fig. 7.—Drilling-machine for boiler stayholes.

he pinion while the latter is kept in place by an annular
W the screw T terminates in a point J, which can be
·e, such as is used for drilling with a ratchet-brace. The
-ed to the flange of the motor M, and thus forms a long
-losed lubricators insure the bearing being properly oiled,
be held. In the base G of the motor are slotted holes for
machines are made of steel and phosphor bronze. The
the 1 horse-power drill and 62 lbs. for the ½ horse-power
ed period have proved that, in the case of a large armor-
ular system, and consequently of very complicated design,
e by these small hydraulic machines is at least 25 per cent
ar holes that can be drilled in the same time by stationary
ast six or seven times greater than the number of similar
y ratchet-braces. In the 1 horse-power machine the motor
It drills holes from 1⅝ up to 2 in. diameter. The ½ horse-
ions per minute and drill holes up to 1¼ in. diameter.
ines, Grinding Machines, Seeders and Drills, and Watches

s DRIVEN BY STEAM OR AIR.—*The Sergeant Tappet-Drill.*—
ive, moved by direct contact with the piston. It is used in
ret, and where the rock is reasonably soft, such as slate, sand-
e valve is of rocker form, and is moved by shoulders on the
e in one piece.
jer" *Rock-Drill.*—In the invention and design of this ma-
a better steam distribution than had before prevailed in ma-
resulting differences between this machine and others are as

machines the motion of the piston is arrested at the conclu-
stroke by a live-steam cushion, obtained by giving the valve a
is machine the piston is stopped (so far as is possible so to do)
otained by closing the exhaust port soon after the return stroke
n thus compressed forms a portion of that used to effect the
. In "tappet" machines the steam is used without expansion.
ntroduced to any desired extent. 3. "Tappet" machines strike
ine strikes an uncushioned blow.
ecessity with "tappet"-valve gears—this necessity arising from
The length of stroke of a rock-drill is not constant. As the
the cylinder must be correspondingly fed forward, but to effect
rity is found to be an impossibility. The effect of this irregular
y the point marking the end of the stroke of the piston—the ap-
ower cylinder-head varying from stroke to stroke. Moreover, in
rtain circumstances, it is occasionally desirable to be able to feed
to shorten the stroke still more than is actually necessary to ac-
arity of feed. In brief, the machine must be able to take strokes
mal length without failure; to trip its valve, in order to continue
his circumstance has usually been provided for by simply giving
ead at the *lower* end of the cylinder, tripping the valve at a point
the end of the shortest stroke to be allowed, and then submitting
power due to the cushion thus introduced into all strokes of usual



-Steam drill—valve motion.

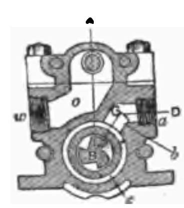
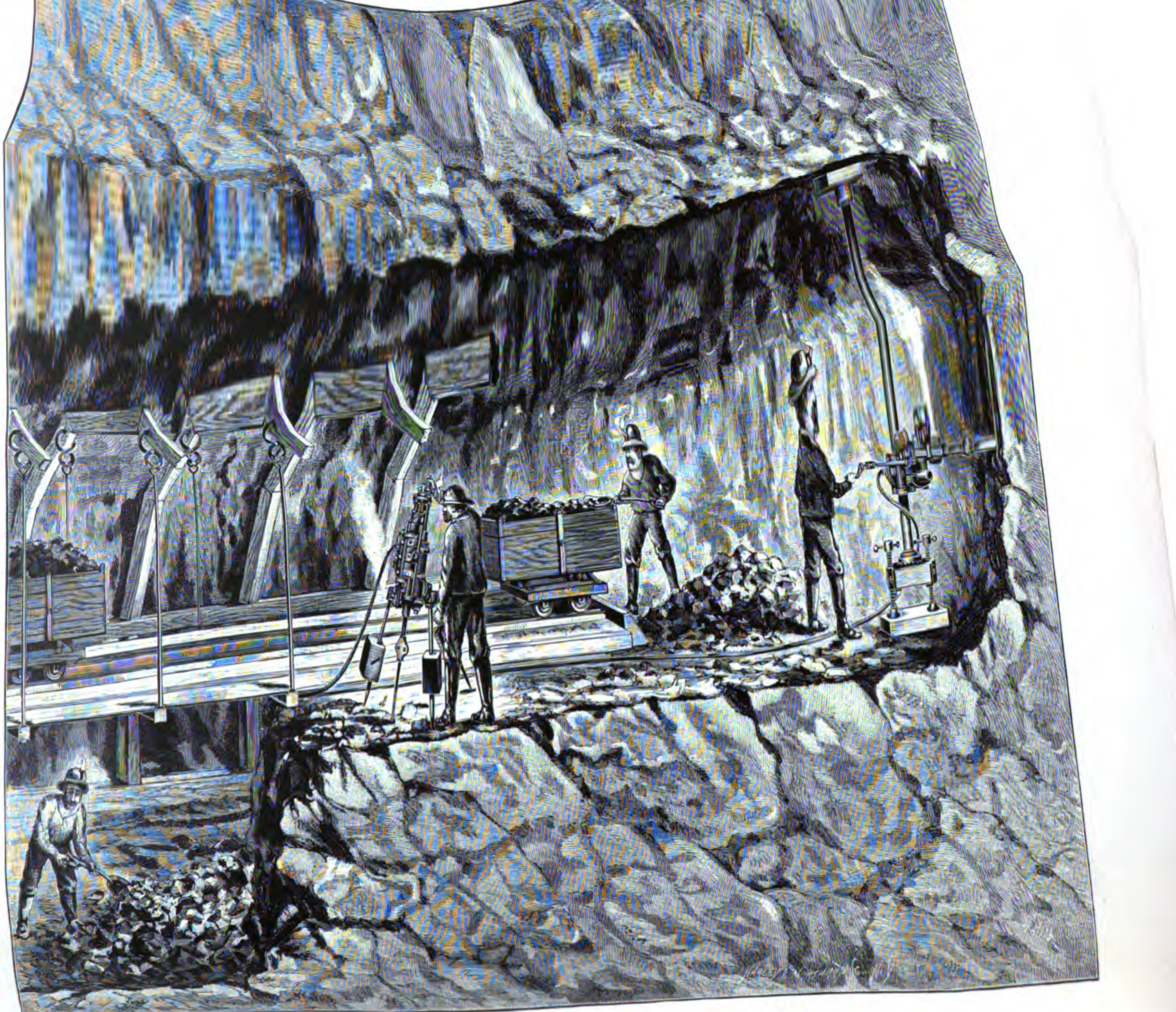


FIG. 2.—Cross section.

about to be described, provision has been made for this irregular feed
it nevertheless, when full-length strokes are made, the valve does not
tted below the piston, until the actual delivery of the blow.
re longitudinal sections taken on the broken line $A\,B\,C\,D$ of Fig. 2,
ing shown in a number of successive positions. Fig. 2 is a cross-sec-
Fig. 3.
has just completed its striking stroke and is ready to commence its
am which effected the preceding striking stroke has been exhausted
which forms the only exhaust port for the upper or left-hand end of
ers at the supply nozzle a, flows through the longitudinal groove b in

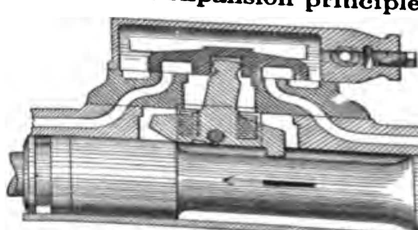


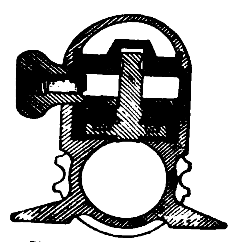
DRIVING THE NIAGARA TUNNEL BY RAND ROCK-DRILLS.

wn indicator diagrams taken with the machine operated by compressed ally reproduced from the original pencil-lines, and being taken at work-de-open throttle, unrestricted speed, and full-length stroke, illustrate the ne. At p in the upper diagram the piston is in the position of Fig. 3. At q the exhaust port h is closed and compression begins; at r the port k is opened, full-pressure steam enters, stops the piston at s, and reverses the valve; at t the port i is closed and expansion begins; at u the port h is opened and exhaust takes place. At the lower end of the cylinder there is no gradual rise of pressure like that from q to r. At this end the rise of pressure is practically instantaneous, and the result is the undulations of the lower diagram. While, however, the upper side of the latter diagram is about valueless, the lower side renders clear the action which it is desired to show; as stated, the machine was running at its full stroke—as near to its lower head as was considered safe—nevertheless, there is no lead whatever shown. At v the exhaust from the upper end of the cylinder occurs, and the crossing of the two exhausts produces the flutter shown. The port d is also opened at v, but it is clear that steam is not admitted until the end of a the stroke is reached.

am—rock-drill.

ed that the point of cut-off depends upon the position of the ports e i, linder, and can be varied at will in the design and in the two ends of the tly. The effect of the cut-off on the striking stroke is to diminish the ile the effect of the absence of cushion is to increase it. The former may latter, so that the blow struck is precisely the same as in cushioned-blow urse obtained with a smaller consumption of steam. On the other hand, e employed on the striking stroke, thus giving the full effect of the increased power. It is freely recognized that fuel is but one of many items in many situations speed of execution far outweighs any economy in fuel sed through the use of the expansion principle. To meet both situations ny and care lead-sses of ma-made, one oth strokes up-stroke achine is nizer" and gger," and s the situa-





ustrate the f the well-drill. The construction will be manifest from the figures. The object

FIG. 8.—Little giant drill.

FIG. 9.—Section.

obtain renewable bearings for the rocker-pin, and thereby provide for

Eclipse" Rock-Drill (Fig. 10 and full page plate).—For a clear under-e-motion of this drill, refer to the cut on the following page. The prin-achine are the cylinder A, the piston B, the valve and chest C. is in form a common steam-cylinder, with its live-steam ports P and P', The two dotted circles F F' represent open passages in the cylinder, l with the exhaust port E, and hence the interior of the cylinder between open to the atmosphere. The two passages D D' are brass tubes opening space in the steam-chest at each end of the valves to the interior of the space between F and F'. The piston B, a common engine-piston, moves e cylinder, and has a stroke from X to Y. This piston has a long bearing ken in its center by the annular space S S', making an open space or it. The length of the space is such that, wherever the piston may be in ace is at all times open to one of the passages D D', and hence to one of h leads by way of the exhaust port E to the open air. S S' therefore is carried up and down with the piston. When the piston is on the up-one of these passages, and when on the down-stroke to the other. The d, and has a hole through its longitudinal axis, through which passes the to guide the valve in its motion back and forth, and which by means of rolling on its seat. In the bottom of the steam-chest there are two cored the tubes D and D' with the ends R' and R of the valve. These passages that R is connected with D' and R' with D. Now refer to the above iston has completed the up-stroke; the valve has been reversed, and the ke a blow. We admit the steam through the chest to the valve at a point paces at O N and N' are in one, the steam will encircle the valve, bearing t through the excess of pressure at O. Escaping over the top of the valve-

...upy R'. This being connected with D, and D being closed by the lower ...here no outlet. Now, R being connected with D', and as D' is now open ...st-chamber, the space behind the valve-flange at R is free to the exhaust; ...m pressure in R' holds the valve close at R so long as D' is open to the

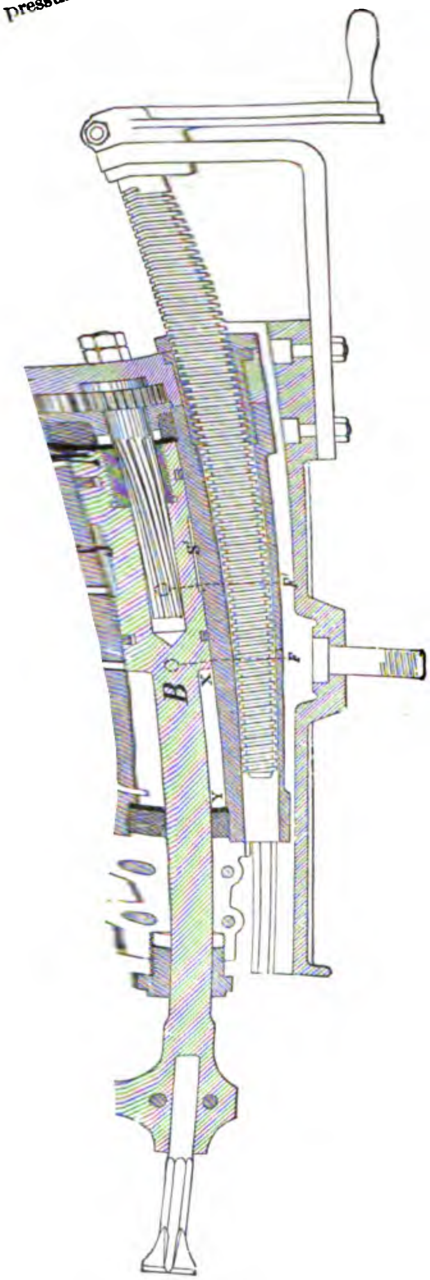


FIG. 10.—Ingersoll "Eclipse" rock-drill.

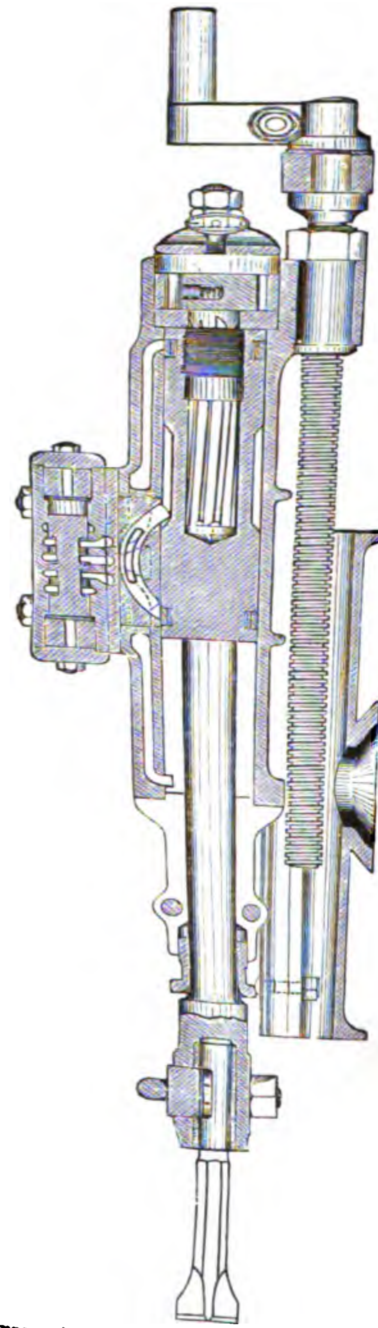
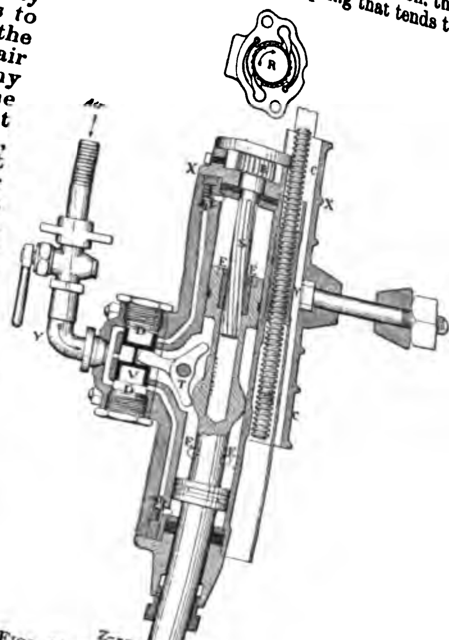


FIG. 11.—Sergeant auxiliary valve-drill.

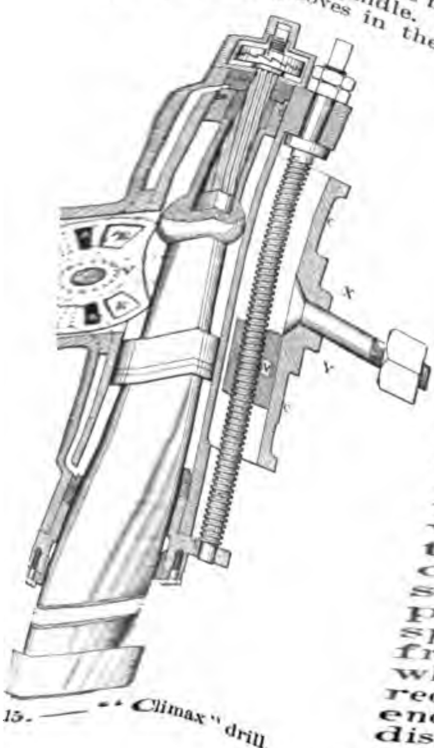
...sage. Therefore, the valve must remain in its present position until the ... port P' being open to the live-steam chamber in the valve, and the port ...the steam passes through P' into the cylinder at M, and pressing upon the ... drives it down. As the piston moves down, this piston exhaust-passage

corresponding valve at the other end of the cylinder is full open for the admission, the ...ng air pressure being greatly in excess of the strength of the light spring that tends to close the non-return valve. This action takes place alternately at each end of the cylinder.

When the inlet slide-valve *V* has been moved by the tappet to either end of its travel, so as to close one of the admission-ports and open the other, it is retained in that position by the air pressure acting upon its admitting end, and any movement is thereby prevented during the time that the boss on the piston-rod is not in contact with the tappet. The slide-valve is cylindrical, and the cylindrical casing or chest in which it slides is provided with an oil-hole on the outer side and on the inner side has a longitudinal slot in which the arm of the tappet moves. At each extremity of its travel the slide-valve is pressed by the tappet against a stop, consisting of a steel-disk with India-rubber backing. When desired both the valve and the tappet can be reversed end for end, for equalizing their wear. During the inward or return stroke of the drill, it is caused to rotate through rather less than a quarter of a turn by means of a rifled spindle *S* fitted into the back-cylinder cover, and carrying a ratchet-wheel *R* with pawls held up by springs, which allows it to rotate in one direction only. On the spindle works a corresponding bush, fitted in the back end of the piston-rod, in which is also made a cavity long enough to receive the spindle when the piston-rod is at the extremity of its inward stroke. When the drill is making its forward or cutting stroke, the ratchet-wheel and rifled spindle are rotated freely by the bush on the piston-rod; while in the return-stroke they are held by the pawls from rotating, and consequently the drill is now rotated by the bush through the extent of the turn provided in the rifling of the spindle. The drill-cylinder is cast with V-shaped projections sliding in corresponding grooves in the cradle *C* in which it is mounted. The feed is given by a screw worked by hand. The cylinder is 3¾ in. diameter with a stroke of 5 in.; and the weight of the drill unmounted is 308 lbs.



FIGS. 13, 14.—"Rio Tinto" rock-drill.



15.—"Climax" drill.

Stephens' "Climax" Drill.—In the construction of this drill (shown in Fig. 15), one of the principal features is the reversible tappet-valve *V*, which is a flat plate rocking on a center pin, and actuated by a spherical boss on the piston-rod, midway between the two pistons. The valve contains a pair of admission-ports *A*, and a pair of recesses or exhaust-ports *E*, which control two corresponding pairs of ports in the valve-chest face, communicating with the ends of the cylinder and with the atmosphere. On the back of the valve is another pair of recesses or exhaust-ports, corresponding with those on the face, so that when worn the valve can be reversed back and face and upside down; it is then practically as good as a new valve and new tappet.

A second feature is the twisting or rotating device on the rifled spindle in the back end of the cylinder, which consists of a crown ratchet-clutch *R*, whereby the use of pawls is dispensed with. The strain which would come upon a single pawl and tooth for rotating the drill, or upon a pair, is here distributed equally over 15 catches, which all act at the same time, the sliding half of the clutch being all in one piece, and pressed forward against the rotating half by a single spring. This arrangement admits of the clutch being from 1 in. to 1½ in. larger in diameter than a ratchet-wheel in the same cylinder-cover, because no space is required for pawls and springs outside the circumference of the ratchet. The strain, therefore, besides being distributed over a much larger number of teeth, is also removed to a greater distance from the center. Another feature is the insertion of loose adjusting liners

rate of 5 revolutions per minute, and allows of an advance of 4 millimetres per revolution being made. The drilling-machine proper consists of a cylinder and a piston (Fig. 17); the cylinder carrying the drill-rod. By introducing water, under pressure, into the cylinder, the same, and with it the drill-bit, is pressed against the rock. The rotary motion of the drill is imparted by two small hydraulic engines, coupled together under 90°, with differential pistons, and fastened to either side of the cylinder. The valve-motion of these engines is so arranged that the right-hand one steers the left-hand one, and *vice versa*. These engines turn a worm, and by it a worm-wheel, which is connected with the rear end of the cylindrical shell surrounding the pressure-cylinder. This shell carries at its farther end the drill-rod, rotates with the worm, and therefore causes the drill-bit to rotate also. The continuous advance of the drill is effected by the direct hydraulic pressure on the cylinder. The cleaning of the drill-hole is done by the water escaping from the hydraulic engine, and led through the hollow drill-rod to the bottom of the hole.

As further illustrating the principles of the Brandt drill, the following description is given, reference being had to the accompanying engravings:—Fig. 17 is a longitudinal section of the cylinder, with the piston and a cross-section of column. The back part of the cylinder is *uninterruptedly* connected with the pressure-water through the port *a*. Now, if pressure-water is admitted through *b* into the other part of the cylinder and the exit at *c* is closed, the cylinder and with it the drill-rod and bit is pressed forward by a pressure corresponding to difference of the areas of the piston. With *b* shut and *c* open, the cylinder moves backward with a pressure corresponding to the annular area of the piston. With *b* and *c* both closed, the cylinder remains stationary. Fig. 18 explains the principle of the small hydraulic engines, turning the drill. The working-piston is a differential piston. The fore part of the cylinder is continuously connected with the pressure-water through *e*. The distribution of the pressure-water takes place only in the back part of the cylinder by means of a piston-valve. The water used runs off through *a*. Fig. 19 shows the accumulator. The pressure-water is admitted uninterruptedly into the cylinder through the port *a*. If the pumps deliver more water than used, the piston of the accumulator rises above the upper section of the cylinder, allowing the water to escape through *b*. The weight is regulated by the addition of iron plates. The whole machine is supported by a column (Fig. 20). This is constructed after the principle of the hydraulic press, with differential plunger-piston.

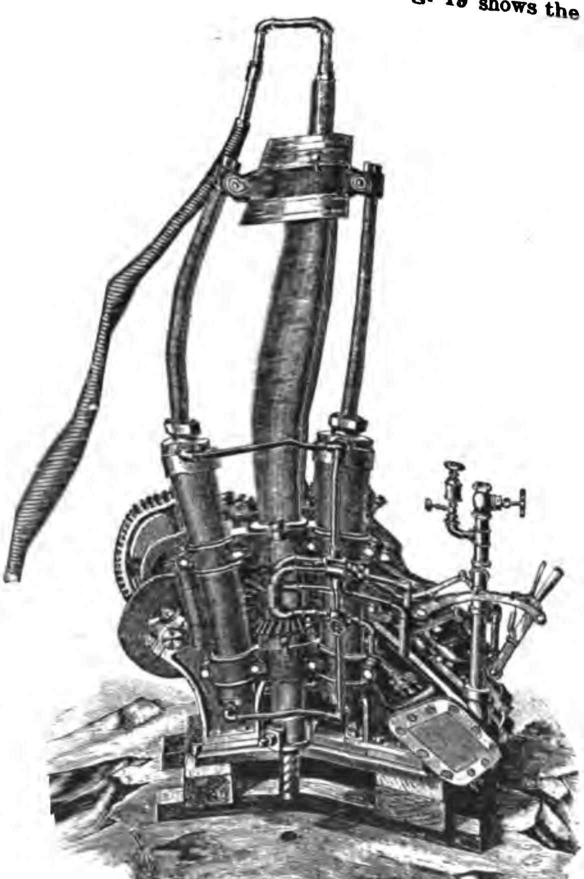


Fig. 21.—Diamond drill.

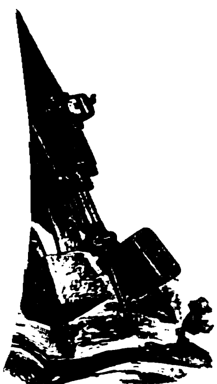
Diamond Prospecting Drills. — The late improvements in these drills relate chiefly to the feeding mechanism, of which two kinds are now in use, the differential and the hydraulic feed:

1. The differential feed. For this feed the machines have a shaft, 5 to 7 ft. in length, of heavy hydraulic tubing, with a deep screw cut on the outside. The shaft is feathered to the lower sleeve-gear. This is a double gear, connecting by its upper teeth with a beveled driving-gear, and by its lower teeth with the release-gear—a frictional gear at the bottom of the short feed-shaft. At the upper end of the feed-shaft another gear is feathered, connecting with an upper gear on the screw-shaft. This last gear is attached to the feed-nut, in the thread of which runs the screw of the screw-shaft, and as the gear of the feed-shaft has one or more teeth than that of the feed-nut, the nut makes fewer revolutions in a given time than the screw-shaft, thus producing the differential feed. The frictional gear on the bottom of the feed-shaft combines with this a frictional feed, making the drill sensitive to the character of the rock through which it is passing, by maintaining a uniform pressure. The severe and sudden strain upon the cutting points incidental to drilling through soft into hard rock with a positive feed is thus avoided.

The tubular drill-rod passes through the screw-shaft and is held firmly by a chuck, the motion of the screw-shaft being thus communicated to the drill-rods and bit.

In order to run the screw-shaft back after it has been fed forward its full length, it is only necessary to release the chuck and to loosen the nut on the frictional gear, thus allowing the

ests a brush which is connected with the conductor, which is common to both other collar is metallic for half of the circle, and the remaining half is in- ie armature wires. Upon this half ring rest two brushes diametrically oppo- and each brush is connected with one of the two remaining conductors leading in the drill. If we now revolve the armature of our generator in a separately ic field, an electric current will flow. Let us say, from the armature to the through one of the two brushes which happens at the instant to be in contact ring along the corresponding conductor to one terminal of one solenoid, let us ar one. Then through the rear solenoid itself and back along the mutual wire ous ring, and then to the armature again. This current in passing through the makes a powerful magnet of it, and this tends to pull the plunger back into a hat the center of its iron portion shall be in the center of the rear solenoid. armature moves forward a half revolution the polarity of its wires is reversed, brush with its conductor is now in contact with the half circle. Consequently, the mutual wire will be in the reverse direction from that of the former wave; the rear solenoid and its conductor, formerly active, are now out of circuit, and the circuit is made through the other conductor and its corresponding solenoid—that is, the forward solenoid. The magnetic action of this solenoid now tends to make the plunger move forward, so that the center of the iron portion shall be in the center of the forward solenoid. Thus we get a reciprocating action of the plunger, and every revolution of the armature of the generator will cause a complete stroke of the drill. By varying the speed of revolution of the generator we can make the drill strike any number of blows per minute we choose. In usual practice 600 blows per minute are found to give good results. An exterior view of a rock-drill of this type is given in Fig. 23. The drills are operated in parallel; three wires lead from the two drill-coils to the generator, comprising two distinct circuits, each circuit including similar coils in the drills. Over these two circuits electrical impulses are sent in alternation. One impulse moves the iron bar or plunger back, and the next moves it forward; thus the drills all move together and in synchronism with the generator. The drill makes about 600 strokes per minute, and the stroke of the plunger is from 3 to 4¼ in. The heaviest single parts of the drill are the tripod-weights, which are about 100 lbs. each.



tric rock-drill.

n order of weight are the two coils, which weigh about 60 lbs. each. The entire drill is the cylindrical casing, which is 38 in. long by about 7 in. in

oele Electric Percussion Rock-Drill consists of two or more coils of copper in iron tube, and a wrought-iron core moving within them. To one end of

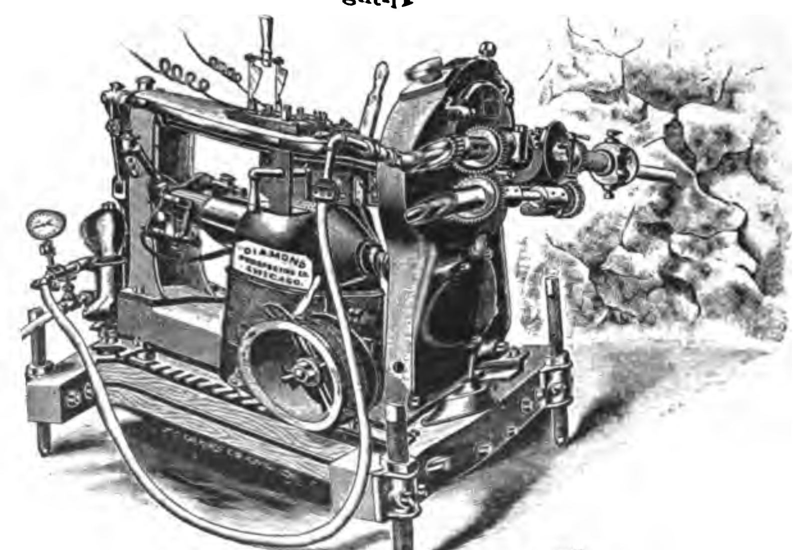


Fig. 24.—Electric diamond-drill.

tened a rifle-bar rotating the drill, to the other a rod carrying the drill-chuck. the drill depends upon the following experimental fact: An iron bar placed

working face before all the *débris* has been removed. In cases where timbering is necessary, and the stretcher-bars have to be lowered to clean up, arrangement is made whereby these, with their machines, can be turned back down on to the carriage. The small receiver shown on top of the carriage is for the distribution of air, and it has two inlets and four outlets, corresponding to the number of drills. The tanks shown on each side are the water-injectors, the injection being effected by admitting air under pressure above the surface of the water.

Rock-drills are mounted in various ways for different classes of work. The full-page plate of Niagara Tunnel (see Niagara, Utilization of) illustrates the Rand drill adapted to

Fig. 27.

Fig. 28.

Fig. 29.

Fig. 30.

Figs. 27-30.—Rand drill—detail of mountings.

various classes of work. Figs. 27 to 30 illustrate various features of these mountings, the chief requirement in all cases being universal adjustability. Fig. 27 illustrates the universal joint of the Rand machine as mounted upon its tripod; Fig. 28 the universal joint by which the front leg of this tripod is attached to the rest of the structure; Fig. 29 illustrates the corresponding universally adjustable parts of the tunnel column; and Fig. 30 the same parts of the shaft-bar.

Dryer, Ore: see Mills, Silver.

Duster: see Milling Machinery, Grain.

Dynamite Gun: see Gun, Pneumatic.

DYNAMO-ELECTRIC MACHINES. The various types of modern machines differ from those of ten years ago in details of construction and improvements brought about by a more thorough recognition of the theory of such machines, and the application of well-defined methods for their calculation in advance of construction.

PARTS OF DYNAMO-MACHINES.—The principal organs of all dynamos are the *armature* in which the currents are generated, and which, as a rule, forms the moving or driven part of the machine; and the *field magnets*, which create the magnetic field through which the armature-conductors pass. To these principal organs we may add the *commutator*, or *collector*, into which the currents generated in the armature are led, and the *brushes* which bear upon the commutator, and are connected with the external circuit.

ARMATURES.—Various constructors have adopted different forms of armatures, which, however, may be grouped under four general heads, as follows:

1. *Cylindrical or Drum-Armatures*, in which the coils are wound longitudinally over the surface of a drum or cylinder. This type of armature is shown diagrammatically in Fig. 1, which illustrates a 4-part drum-armature with closed coil. In practice, of course, the coils thus wound may reach several hundreds in number, with a corresponding number of commutator-bars. Armatures of this type are employed in the machines of Edison, Weston, Siemens (Alteneck), Stanley (alternating), and a large number of others. A modified form of the drum-armature is employed in the Thomson-Houston arc-light dynamo (see below) which has a spherical shape.

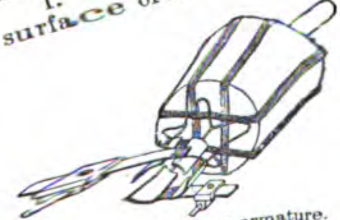


Fig. 1.—Drum-armature.

Drum-armatures, a typical form of which (Weston) is shown in Figs. 54 and 55, are usually built up of disks of the softest charcoal-iron, insulated from each other by layers of tissue-paper, and screwed together to form a solid cylinder, which is keyed to the shaft. The core thus formed is covered with canvas soaked in shellac, and upon it the insulated wires are wound. The object of building up the core with thin disks is to avoid the formation of Foucault or "eddy" currents, which absorb power, and which would quickly heat the armature and destroy the insulation of the wires. In the early types of these armatures teeth were generally employed on the periphery, but were later on abandoned; the practice, however, at present tends strongly to their re-employment, as they serve to decrease the resistance of the magnetic circuit and to aid largely in holding the wires firmly in place.

2. *Ring-Armatures.*—In these the coils are wound around an iron ring, usually mounted

ves to reduce the internal resistance of the machine, and to increase its Open-coil machines are used almost exclusively for constructions in which high potentials rather than heavy currents, as in arc-light machines. INGS.—In the ring, disk, and pole type of armature the winding or wind- continuous and symmetrical, but in the drum-armature there is much mbinations, in order to secure, first, an equal length of wire in each coil; test length of wire capable of giving the required E. M. F. Figs. 3, 4, 5,

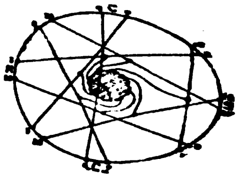


FIG. 4.

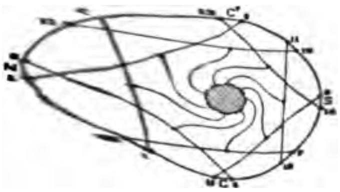


FIG. 5.

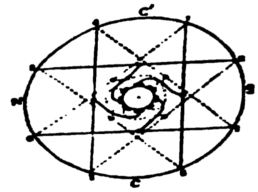


FIG. 6.

FIGS. 3-6.—Armature windings.

methods of armature-winding employed by different constructors. The Hefner-Alteneck (Fig. 4) were wound unsymmetrically, on account of the and better insulation of which it permitted. Subsequently Froelich in- al winding (Fig. 3). Breguet has designed a large number of windings, and 6, and showed that with eight commutator segments eight different ts were possible; that winding should, of course, be selected which, with apacity, will have the shortest length of wire. Breguet calculates that rums the following lengths of wire are necessary for the various systems: 8; Hefner-Alteneck winding, 30·5; Breguet winding, 26; Breguet (an- ; Fig. 7 shows one style of winding of the Edison armature which is

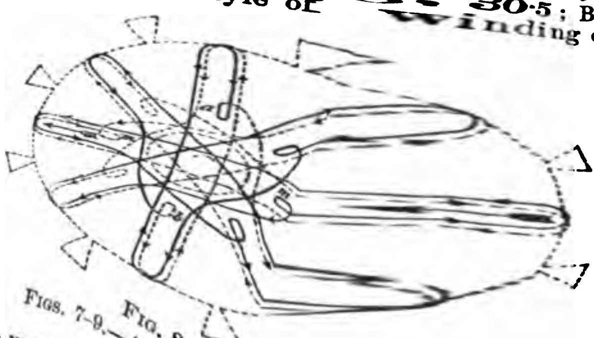


FIG. 8.

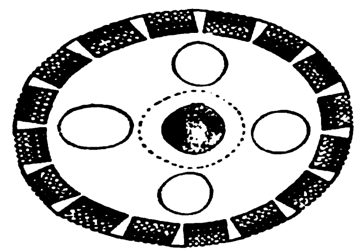


FIG. 9.

FIGS. 7-9.—Armature windings.

has an uneven number of divisions. Fig. 8 shows a diagram of one ing, and Fig. 9 a section through the armature: it will be noted that sively change from outer to inner, thus equalizing the potential gen-

is methods of winding closed-coil ring armatures. The simplest, of y sections as there are collector rings, and connect the junction of con- . Another method is to wind twice as many sections as there are bars in n being united either in series or parallel with that diametrically oppo- united being treated as a single section in the coupling up of the ring. es are employed in multipolar fields, a variety of methods of connection are possible. That of Mordey is shown in Fig. 10. It consists in adding to the usual Gramme winding a system of cross-connections between those portions of the armature-circuit which arrive simulta- neously at equal potentials. This may be done by cross-connecting either the bars of each collector or the wires of the winding. In 4- pole machines each bar must communicate with that situated 180° from it; in 6-pole machines, with those situated at 120° from it. Mordey's method, as applied to a 4-pole machine, is shown in Fig. 10, which shows connections of a simple 8-part ring. It will be noted that only two brushes, and these at 90° apart, are required to collect the currents.

Another method suggested by Prof. Perry, in 1882, is applicable only to armatures wound with an odd number of sections. The dia- s to an 11-part armature in a 4-pole machine. In this method the suc- coil are not connected together, as in Gramme's winding, but each coil

10, the two magnetic circuits being separated by the qually for many forms of flat-ring machine; but in ring-armature. The diagram will serve most of these the poles at the two flanks

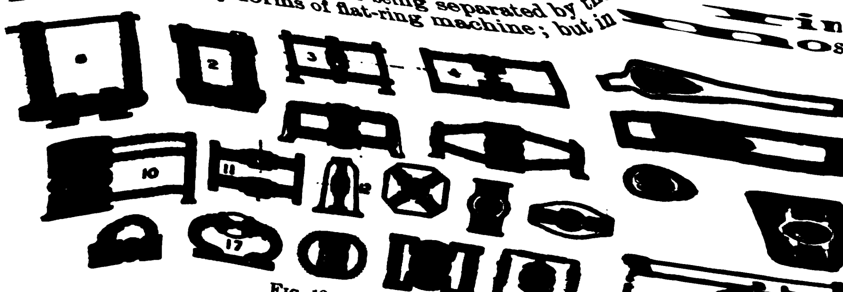


FIG. 12.—Field-magnets.

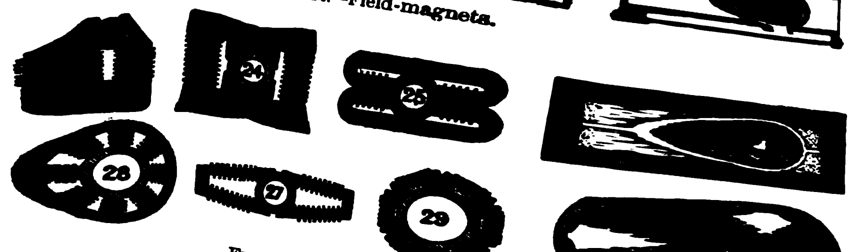


FIG. 13.—Field-magnets.

FIG. 14.—Field-magnets.

of the ring are joined by a common hollow pole-piece, embracing a portion of the periphery of the ring. No. 5 shows the well-known form of Siemens, with arched ribs of wrought iron, having consequent poles at the arch. The circuit is here of insufficient cross-section. No. 6 depicts the form adopted by Weston; and very similar forms have been used by Crompton, and by Paterson and Cooper. There is a better cross-section here. No. 7 is a form used by Bürgin and Crompton, and differs but slightly from the last. It has one advantage, that the number of joints in the circuit is reduced. No. 8 is a form used by Crompton, Kapp, and by Paterson and Cooper. No. 9 is the form adopted in the little Griscom motor. No. 18 is a further modification due to Kapp. No. 19, which also has consequent poles, is used by McTighe, by Joel, and by Hopkinson ("Manchester" dynamo) (see below), by Clark, Muirhead & Co. ("Westminster" dynamo), by C. E. Brown (Oerlikon) (see below), by Blakey, Emmott & Co., and in some of Sprague's motors, but with slight differences in proportions of the details. The main difference between No. 19 and No. 6 lies in the position selected for placing the coils, No. 19 requiring two, No. 6 four. No. 20, which is the design of Elwell and Parker, is a further modification of No. 8. In No. 8 (Gramme) it is usual to cast the pole-pieces and end-plates, but to use wrought iron for the longitudinal cores. The requisite polar surface must be got by some means, and, when the core was made thin, the two courses open were either to fasten upon the core a massive pole-piece (Nos. 1, 3, 4, 6, 7, 19, 20), or else to arch the core No. 5 so that its lateral surface was available as a pole. Now, however, that it is known that massive cores are an advantage, the requisite polar surface can be obtained without adding any polar expansion or "piece," but by merely shaping the core to the requisite form (No. 8). This must not be regarded as a mere thinning of the magnet; for, though mere reduction of cross-section at any part of the circuit would reduce the magnetic conductivity, reduction of the thickness for the purpose of bringing the armature more closely into the circuit will have quite the opposite effect. Nos. 1 to 15 illustrate forms of field-magnet having *salient* as distinguished from *consequent* poles. No. 11 is the double Gramme machine designed by Deprez. Nos. 12 and 13 are two of the innumerable patterns due to Gramme himself. These are both of cast iron; and it will be noticed that in No. 13 there are no joints, it being cast in one piece. No. 14 is the form used by Hochhausen, and is practically identical with 21, save in the position of the axis of rotation. The iron flanks of No. 14, however, tend to produce a certain short-circuiting of the magnetism by their proximity to the poles. No. 15, used by Van Depoele, is similar. No. 16 is the form used by Sylvanus Thompson in small motors, and is cast in one piece. The semicircular form adopted for the core was intended to reduce the magnetic circuit to a minimum length. No. 17 illustrates the form used by Jürgensen, having salient poles re-enforced by other electro-magnets within the armature. No. 21 shows in section the double tubular magnets of the Thomson-Houston dynamo, the spherical armature being placed, as in Nos. 12, 14, and 15, between two salient poles. There is a curious analogy between Nos. 21 and 19; but they differ entirely in the position of the coils. No. 22 is a design by Kapp, in which there are two salient poles of similar polarity, and two consequent poles between them, one pair of coils sufficing to magnetize the whole quadruple circuit. Almost identical forms have been employed by Kennedy ("iron-clad" dynamo), and by Wenström. No. 23 (Fig. 13) is a type which, used long ago by Sawyer and by Lahmeyer and by Lontin, has recently become a favorite one, having been revived almost simultaneously by Gramme ("type supérieur"), by Kapp, by Siemens ("F" type), by Cabella ("Technomasio"), and lately by Paterson and Cooper. No. 24 is Brown's very massive form. No. 25 is a design by Kennedy, known as the "iron-clad" dynamo; the iron cores are forged

but more recently the application of carbon brushes has overcome many difficulties connected with the commutator. Another class of commutator, sometimes employed for self-exciting, alternate-current machines, is shown in Fig. 15.

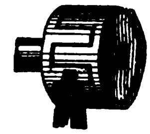


FIG. 15.—Commutator.

Brushes.—These are employed to take the current from the commutator-bars and deliver it to the working-circuit. Various forms are employed, among them those shown in Fig. 16. The object in all cases is to secure as good a contact as possible between commutator and brush, and hence the latter has been given the forms shown. In *A* a number of copper wires are grouped into a brush soldered together at their ends. In *B* a flat strip is slit longitudinally, while in *C* a series of strips are soldered together and bear edgewise on the commutator. Within the past few years "carbon brushes," as they are called, have come into extensive use, especially in connection with motors. They are made up of a pressed mass containing coke and a certain percentage of plumbago, which gives them excellent lubricating qualities. Their great merit, however, lies in the fact that they do not burn perceptibly, and hence have a long life, at the same time protecting the commutator from wear. Brushes made of copper wire-gauze are also largely in use.

FIG. 16.—Brushes.

Method of connecting Armature and Dynamo.—Excitation.—Governing.—The methods of the connection of the armature to the field-magnet, as well as the mode of excitation of the dynamo-machine, are most intimately connected with its regulating properties. Magnetism may be excited in the field-magnets in various ways.

1. *Magneto-Dynamo.*—This type, shown in Fig. 17, is the oldest employed, and has permanent steel magnets. This form is still used in small machines for special purposes, as in magneto-calls, telephones, etc., and for experimental work, but has long been discarded in large machines on account of the great weight of the machine for a given output, and also because the permanent magnets gradually diminish in strength, and thus reduce the output of the machine. On account of their simplicity, however, permanent magnets are still employed in machines of the De Meritens type, intended for lighthouse work. (See *Alliance, Pixii*, and other magneto-machines, pp. 519, 520, old edition.)

2. *Separately Excited Dynamo.*—This type was employed by Faraday and later by Wilde in 1866 (see p. 522, old edition). This machine, as well as the magneto-dynamo, has the field-

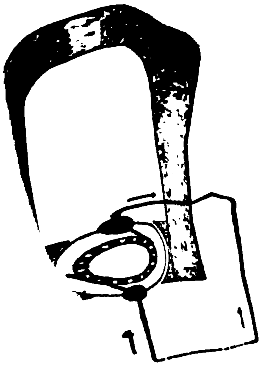


FIG. 17.

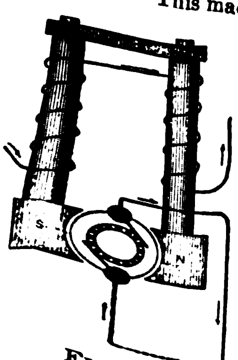


FIG. 18.

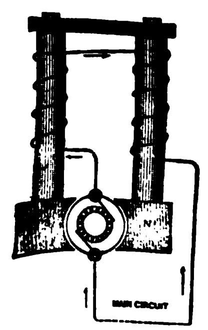


FIG. 19.

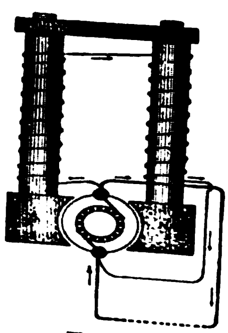


FIG. 20.

FIGS. 17-20.—Types of dynamos.

ism constant, and hence the E. M. F. generated is independent of changes in the ex-
rcuit. Both the preceding types of machines may be regulated either by altering the
by varying the magnetism passing through the armature. Fig. 18 shows the method
tion.
ies-Dynamo.—This is the type of machine now generally employed for arc-lighting,
i is specially adapted to furnish currents of constant strength. As shown in Fig.
mature, the external circuit, and the field-magnet windings, are all connected in
hat the current is of equal strength in all parts of the circuit. This type of ma-
not begin to generate current until it has attained a certain "critical" speed, as
speed the magnets do not become excited; this speed depends upon the resistance
it. This type of machine is also liable to have its polarity reversed; hence, it is not
electro-plating or charging storage-batteries.
-Dynamo.—This type is the one most generally employed at the present time for
ential machines, such as are used for incandescent-lighting. The connections are
g. 20. The armature here feeds two independent circuits: (*a*) the main circuit,
ts with the lamps, and is indicated by the heavy line and arrow; (*b*) the shunt
energizes the field-magnets. The shunt circuit consists of fine wire, usually

These plates when pressed together conduct well, but when the pressure is diminished their imperfect contact partially interrupts the shunt circuit and increases its resistance. When A rises and compresses C, the current is diverted to a greater or less extent from the field-magnets, which are thus under control.

For regulating the potential of constant potential (incandescent-light) shunt-machines, Edison first employed a variable resistance placed in series with the field-magnet coils. The arrangement is shown in Fig. 23. As the potential increases, resistances are thrown by moving the handle of the rheostat R, which diminishes the current in the field-magnet coils, and hence their magnetic power, and thus reduces the potential of the machine to its normal value. On a decrease of potential, due to increased load, the rheostat resistance is reduced, which reverses the action just stated. The operation of the rheostat has also been carried out automatically in various ways. Besides the methods just enumerated, others have been employed. In Lane-Fox's regulator, a high-resistance relay is connected as a shunt to the mains, and actuates the rheostat as described above. Regulation can also be effected by winding the field-magnets in sections, and cutting these sections in, or out, in proportion to the load. This method has been employed by Deprez, Brush, Hochhausen, Van Depoele, and others. Still another method consists in placing a magnetic shunt across the field-magnets, and thus diverting the lines of force from the armature as the load decreases. This has been carried out by Goolden and Trotter in their constant-current machine (see below).

Regulation can also be effected by governing the steam-engine, so that its speed is exactly proportional to the load. In Richardson's electric governor (Fig. 24) the valve which admits steam to the engine is a double-beat equilibrium valve E; its stalk passes upward and is acted upon by a plunger R, which is pressed down by the shorter arm of a lever L, which is in turn connected with a long vertical spindle having a weight C at its lower end, and at its upper end carrying the iron core B, surrounded by the solenoid A. A spring S counterpoises the slight upward pressure of the steam on the valve. When the current passes through the solenoid A it lifts the core B to a certain height, and admits to the engine a sufficient quantity of steam to drive the engine at the speed requisite to maintain the current. Should the resistance of the circuit be increased by the introduction of additional lamps, the core B will fall a little, thereby turning on more steam, until the speed has risen to that now necessary. For additional safety a separate electro-magnet a is added, which, when in action, holds up the heavy iron block b. Should the circuit from any cause be broken, the block b instantly descends and cuts off the steam. Similar engine-governors have been devised by Willans, Jamieson, and others. Further information respecting electric governors, and their actual applications in various installations of electric-lights, may be found in the following papers: A. Jamieson, Electric-Lighting for Steamships, *Proc. Inst. Civ. Engrs.*, vol. lxxix, session 1884–'85, Part I: F. W. Willans, The Electric Regulation of the Speed of Steam-Engines, *Proc. Inst. Civ. Engrs.*, vol. lxxxi, session 1884–'85, Part III. (See also *Thompson's Dynamo-Electric Machinery*.) Dynamometric governing has also been proposed, the regulation being effected by the action due to the variation in torque with varying load. Governing by steam-pressure has also been proposed. In this system the steam-pressure is kept constant, and equal quantities of steam admitted in each stroke between the speed.

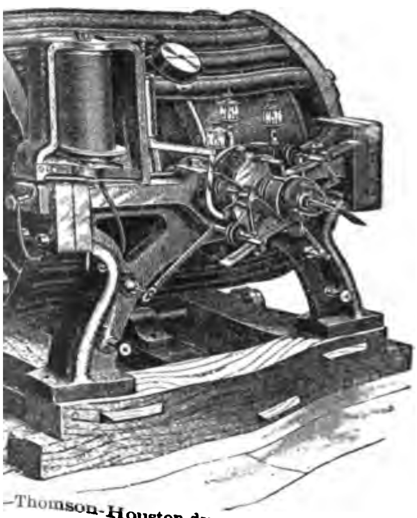
Fig. 24.—Electric Governor.

The principles above enumerated have been carried out in a large number of designs of machines, each having its special peculiarities and advantages. For the sake of obtaining a better understanding of the various types, we have in the following grouped dynamo-electric generators primarily into two divisions: continuous-current and alternate-current dynamos.

CONTINUOUS-CURRENT DYNAMOS.—These may be divided into (a) *constant current* and (b) *constant potential* machines; the former were those first brought to practical perfection, hence we shall take them in that order, giving examples of the machines in most general use, together with the regulating methods employed for keeping the current constant.

The Brush Arc-Light Machine.—The most characteristic feature of the Brush machine (see p. 527, old edition) lies in the form and construction of its armature, which consists of a built-up iron ring, the cross-section of which is generally rectangular, but in the direction of its circumference it is alternately wide and narrow, as shown in Fig. 25, which represents the armature-ring and explains its construction. On reference to this figure it will be seen the ring is divided up into as many sections as there are bobbins to be wound by a number of rectangular depressions or grooves; in these the coils of insulated copper wire are wound until the groove is filled up, and the flat, converging recesses become flush with the surface of the intermediate thicker portions or pole-pieces, by which they are separated from one another. All the coils are, like those in the Gramme machine, wound in the same direction. Fig. 26 is a diagram illustrative, not only of the distribution of the coils around the ring, but of the method by which the connections are made; the inner ends of each of the coils is connected by a wire to the inner end of the corresponding coil at the opposite end of the same diameter of the ring, and the outer ends of all the coils are brought through the shaft of the machine, and are connected to corresponding portions of the commutator, where the currents are collected by suitably placed copper plates. Referring to the diagram, it will be seen that the inner end A^1 of the coil 1 is connected to A^5, which is the inner end of the coil 5; A^2 is connected to A^6, A^3 to A^7, and so on round the ring, and the outer ends, B^1 B^2 B^3, etc., are

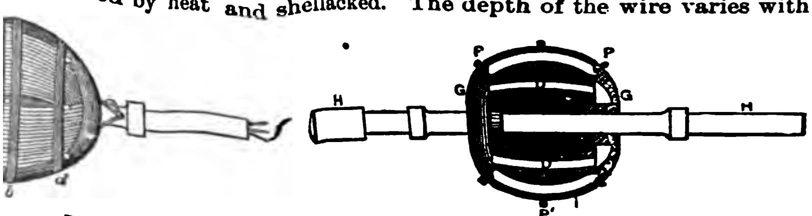
sist of two large hollow castings. The large flanged portions of the
ıgnetically by a series of bars of soft iron, and are firmly held in place



–Thomson-Houston dynamo.

by bolting to the side-frame, which also affords feet for the machine and sustains the shaft in its bearings.

The armature, spherical in form (Fig. 30) is nearly inclosed. The commutator and air-blast mechanism, therefore, occupy positions upon that portion of the shaft outside the bearing. The wires, three in number, from the armature helices are brought out through the hollow shaft and connected to the commutator at the end of the shaft. The armature-core consists of an iron shell, having the form of an oblate spheroid, mounted centrally upon the shaft, as seen in Fig. 31, the shaft H H passing through the axis of the spheroid. The polar portions are formed of two thin iron castings, placed, as shown, at G G, and keyed firmly to the shaft. Between these flanges, and supported by them,
om, are a series of cast-iron bridges D, generally 12 in number, and
nces apart. The bridges are formed with feet that enter corresponding
l faces of the flanges. Outside the bridges is wound a quantity of well-
e I, scaled by heat and shellacked. The depth of the wire varies with



FIGS. 30, 31.—Thomson-Houston armature.

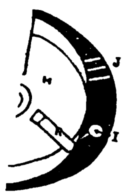
chine, and, when all on, completes the form of the spheroidal arma-
ed with several layers of insulating paper, and then is wound with in-
o facilitate this winding, hard-wood pins P P are carried by being in-
the flanges near their periphery. The core so formed is wound with
e another at the polar portions, and being divided centrally by the
ough the core. To secure mechanical and electrical equality of the
he following procedure is adopted: The first half of the first coil is
the second coil is next wound; the whole of the third coil is then
of the second coil is then wound; finally, the second half of the first
g, and produces an approximately spherical outline, as shown in Fig.
ughly insulated, and are interwoven with tapes, wherever necessary to
inally, a strong brass-wire binding is applied, consisting of two central
al bands d d, wound around the armatures circumferentially.
n the inner ends of the coils are joined together permanently at a,
nds f are carried through the shaft to the commutator. By this wind-
ces of electric potential are found only upon the outside wires, tne
favor of retention of insulation under all conditions. The position of
ture is such that they follow each other in similar electrical sequence
apart, an arrangement which gives, with the small number of generat-
nate continuity of effect. The three free ends are carried out through
l insulated while passing to their connections at the commutator near

nsists of a copper ring, slit into three segments of 120° nearly. These
ntly mounted upon a metal frame, which gives the segment its posi-
frames G G G (Figs. 32 and 33), for the support of the segments, are
flanges J J, but thoroughly insulated from them. The flanges J J are
the shaft, and covered with a layer of vulcanite. The segments are
emoval of screws passing through lateral ears extending from each

ted so promptly that a machine may have all its lights shunted at once without isteady power does not practically injure the steadiness and uniformity of the rent.

e novel features of the machine is the use of the air-blast attachment to the commutator. ted for the purpose of permitting the use of electromotive forces up to 2,000 volts ile a free oiling of the commutator-surfaces is still permissible for diminishing le commutator being used, and that containing but three segments. It is based scovery by Prof. Thomson that a strong jet of air of small amount can effectually onducting line of particles tending to bridge the commutator-slots, and cause the rge termed "flashing." Small nozzles are mounted directly opposite the tips of t positive and negative commutator-brush. At the moment the slot in the com- sses the tips of the brush, a puff of air is sent through the slot and repeated at

These small puffs are furnished at the proper instant by a small rotary, positive- anism (Fig. 39), which is mounted upon the journal-box at the commutator side of



-Air-blast.

the machine, and within which are carried by a slotted hub H (rotated by the shaft S) a set of three hard-rubber wings loosely placed in the slots in the hub at $R\ R\ R$, 120° apart. An inclosing case of interior elliptical outline is divided by the hub H into two lune or crescent-shaped chambers, into which the rubber wings are thrown by centrifugal force during rotation. Inlet openings are provided at $I\ I$, covered with fine wire gauze to exclude particles. The outlets are at $J\ J$, and communicate with the nozzles over the commutator-slots. By this construction, when the parts are correctly set, six puffs of air are obtained at every rotation, three from each nozzle, alternating in succession from the nozzles, and corresponding to the times of passage of the commutator divisions or slots past the ends of the forward brushes. The ad- obtained by the use of the air-blast for high electromotive-force currents are great. as all that sensitiveness to oil which is generally present in such cases. The Thom- ston machine can be run with a steady stream of oil pouring upon the commutator, e being no carbonizable material collecting at the commutator segments, no fear of cuits of armature-coils need be apprehended from that cause.

1 used as a generator, the armature-coils successively traverse the opposed field-spaces, impulses so produced in them find connection through the commutator-brushes to the The armature-helices act for a portion of the time in multiple arc of two coils, as ey are traversing field-spaces where the impulse is considerably below the maximum, alone or in series with the other coils, when they are producing their maximum im-

FIG. 40.—Ring-armature.

These actions necessarily result from the il or three-branched armature system. The f application of the brushes is such that ie electromotive force of one branch or coil en below that of the branch or coil which it in sequence during rotation, the current sferred to the latter, and the former coil, gh it has not yet reached neutrality, is in- put by the commutator into connection he opposite commutator-brushes, there to supplanting that branch which is about to said brushes. This mode of carrying off the its will be understood by reference to Fig. t possesses the apparent anomalous condi- f putting a commutator segment, just before the coil or branch to which it is attached eached neutrality of electrical action, into momentary contact or electrical connection both positive and negative brushes of the machine. This condition, however, gives rise to no perceptible inconvenience, and this latter fact is accounted for by the powerful effect of the field-magnet helices in preserving the volume and direction of the current at the instant of the connection just referred to.

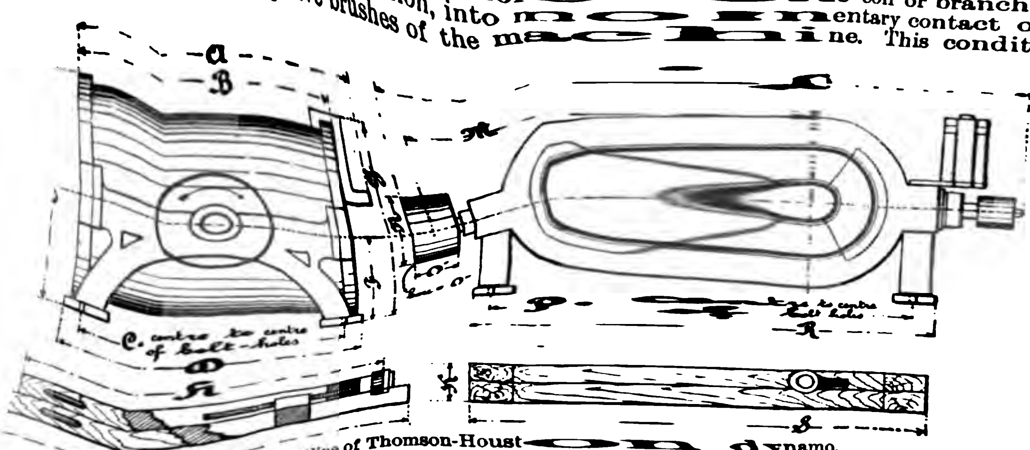


FIG. 41.—Outline of Thomson-Houston dynamo.

During regulation the positions of the brushes are so altered as to enlarge this period of connection, and so diminish the available electromotive force

a special piece of apparatus, called the analyzer, and which is placed beween the disk and collector. The three wires of each coil come from the center of the armature to an insulated disk: wire 1 passes on straight to the collector-bar; wire 1′ is wound in involute on one side of the disk, and runs thus to bar 1′; wire 1″ passes through the disk, is wound backward through 120°, and terminates at bar 1″. In this way all the wires are arranged side by side on either face of the analyzer, and no mistakes are to be feared. It is not necessary to enlarge further upon the practical advantages of these arrangements, allowing as they do very satisfactory working of the collector. It would be impossible otherwise to stop sparking without increasing the number of coils, or increasing the distance between the successive poles. Several Desrozier machines have been built by the firm of Bréguet, and placed on board the French ironclad Formidable. These machines weigh 2,640 lbs. each, run at 350 revolutions, and have an output of

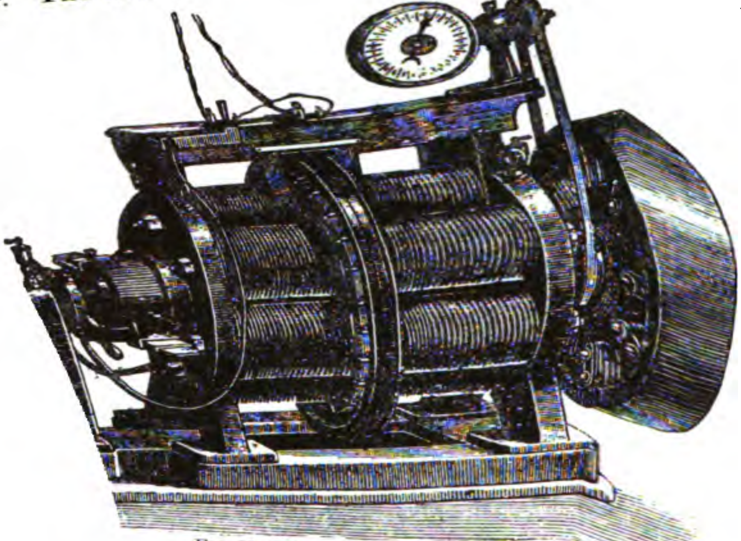


FIG. 79. Desrozier dynamo.

at 70 volts; their electrical efficiency is 82 per cent, and their commercial efficiency is 78 per cent. It varies very little with the work. According to the inventor, it is that the efficiency of the Desrozier dynamo would be considerably higher if to meet ordinary commercial requirements.

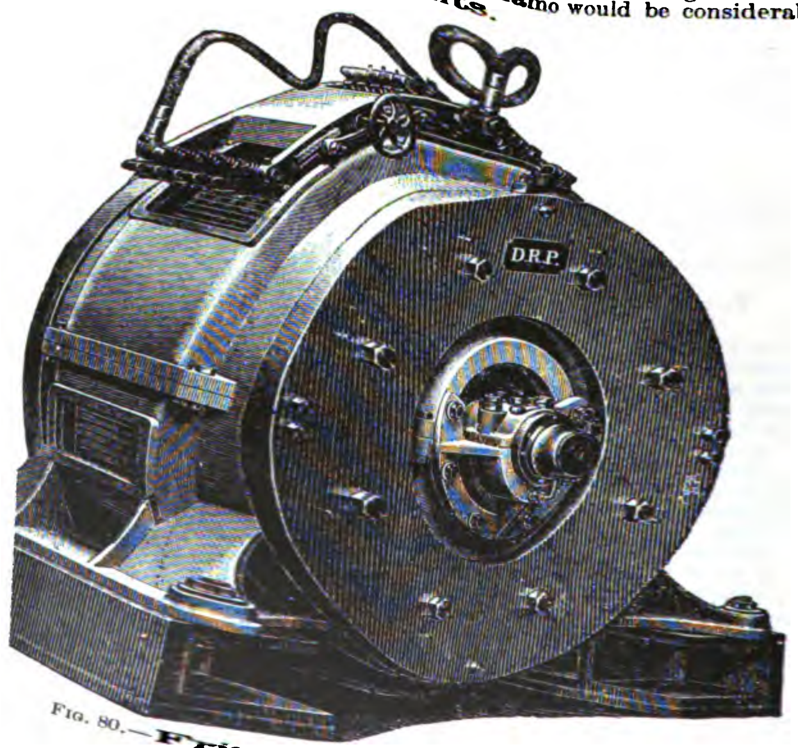


FIG. 80.—Fritsche and Pischon dynamo

of springy strips of metal-foil, is maintained at the two extremities of the periphery. One of the earlier forms of machine, with a single disk 18 in. in diameter, was stated to give 3,117 ampères at a potential of 5·8 volts when running at 1,500 revolutions per min. One of the later machines, in which the "armature" is a cylinder of iron 9 in. in diameter and 8 in. long, is designed to give, at 1,000 revolutions per min., a current of 10,000 ampères at a potential of 1 volt. The electromotive force of such machines increases as the square of the diameter. The theory of the unipolar disk machine has been given by Sir W. Thomson, who has shown that such a machine is not self-exciting except above a certain critical speed, dependent on the resistance of the circuit.

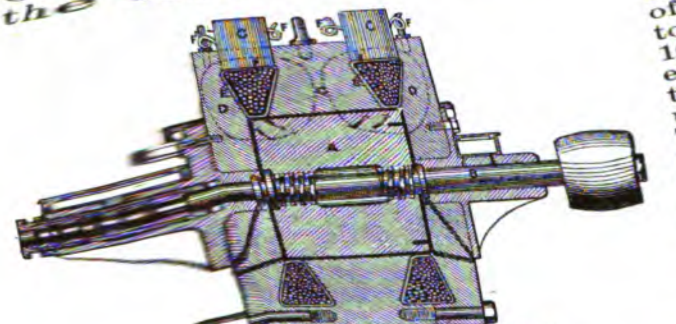


Fig. 82.—Forbes dynamo.

ALTERNATING-CURRENT MACHINES.—In general the methods of mechanical construction adopted in these machines do not differ materially from those of the continuous machine. In the alternating machine, however, the use of the commutator becomes superfluous, the current generated in the armature being led merely to a pair of rings attached to the shaft, and upon which the brushes bear. Special precautions, however, are necessary to avoid piercing of the insulation on the armatures of such machines, and for that purpose mica is now almost exclusively employed. In these machines, also, thorough lamination is imperative.

According to Kapp, if we calculate out the E. M. F. of an alternate-current machine by applying to it the now well-known formulæ for continuous-current dynamos, there will then be a certain numerical coefficient by which the E. M. F. thus found must be multiplied in order to obtain the actual mean alternating E. M. F. of the machine. The value of this coefficient, K, depends chiefly upon the relative width of the field-magnet poles and space between, and also upon the amount of the surface of the armature which is covered with wire. The following table gives the value of K for different cases:

1. Width of poles equal to pitch, toothed armature and winding concentrated in the recesses.................... $K = 2·000$
2. Width of poles equal to pitch, smooth armature and winding spread over the whole surface.................... $K = 1·160$
3. Width of poles equal to pitch, smooth armature and winding covering only one half the surface.................... $K = 1·635$
4. Width of poles equal to half the pitch, smooth armature and winding spread over the whole surface.................... $K = 1·635$
5. Width of poles equal to half the pitch, smooth armature and winding covering only one half the surface.................... $K = 2·300$
6. Width of poles equal to one third the pitch, smooth armature and winding covering only one third of the surface.................... $K = 2·830$

According to the ordinary sine formula, the coefficient is $K = 2·220$, and this agrees fairly well with case 5, which is the one most frequently met with in actual practice.

The Westinghouse Alternating-Current Dynamo (*Incandescent*).—The machine at present very largely employed in the United States for incandescent lighting on the alternating system is that of the Westinghouse Electric Co., shown in perspective, with its exciter, in Fig. 83. The Westinghouse Co. makes five sizes of dynamo, of which the following particulars are of interest:

DYNAMO NUMBER	I.	II.	III.
E. M. F.	1,050	1,050	1,050
Current	35	65	130
Resistance (armature) at 30° C.	·76	·37	·15
" (fields) at 30° C.	14·5	7	3·6
Weight of wire in armature	17	30	60
" " fields	420	....	....
Total weight	4,800	9,000	....
Number of lights	650	1,300	2,600

The No. III has an armature about 2 ft. in diameter and 2 ft. long. It has 16 poles, and runs at 1,000 revolutions per min. The armature plates have each six large holes for ventilation and lightness. The weight of armature is 2,000 lbs. The insulation is mica and copal varnish, which is found to be much superior to shellac or any other material tried.

Fig. 84 is a side view and Fig. 85 is an end view, from which the construction will be easily understood. The field-magnets, bolted to the external frame of the machine, form a circle, radiating inward toward the armature, which is mounted in the center on standards rising from the base. They are of elliptical form, the longer axis of a cross-section of each core being parallel to the armature-shaft, as shown at f and $g\,g$, Fig. 84, the edges of the

cores being shown at *ff*, Fig. 86. The winding of each magnet is opposite to that of the adjacent one, so as to produce north and south polarity. The coils are slipped on the cores after being wound. The armature-core is composed of sheet-iron disks, insulated by paper, and having tubular openings for ventilation parallel to the axis; a great number of these being laid together, the openings registering to form the tubes, and then bolted together by end-plates, as shown. The winding differs from that of the Gramme armature in having no interior wire. The coils consist of single layers of wires wound on the external surface of the core and looped around projections $m^1 m^1$ at the ends, attached to non-magnetic rings o^1, so that the planes of the coils are at right angles to the radii of the armature, and there are no crossing wires at the ends, as in the Siemens, nor wire in the interior of the ring, as in the Gramme; the ends being exposed for ventilation through the tubular openings in the core. Adjacent coils being wound oppositely, as in the field-magnets, as shown in Fig. 87, generate alternating, opposite currents. The coils are insulated from the core with mica, and also covered externally with the same material,

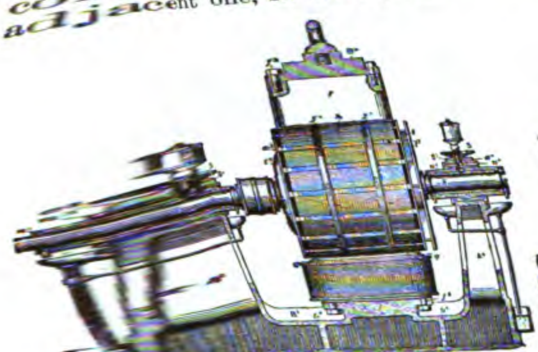


FIG. 84.

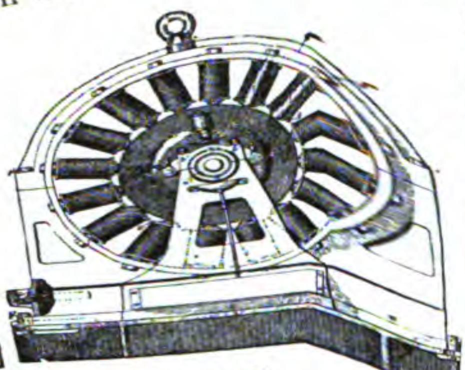


FIG. 85.

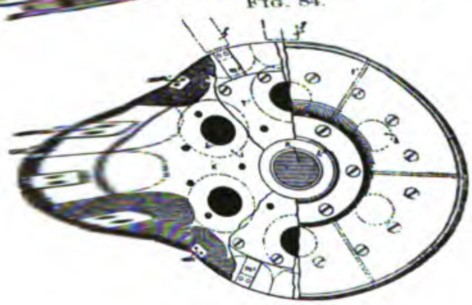


FIG. 86.

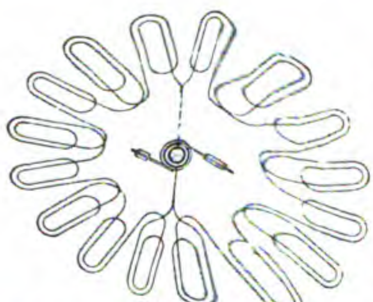


FIG. 87.

FIGS. 84-87.—Westinghouse dynamo—details.

and firmly bound with the bands $j^1 j^1$. The space between the armature and the field-magnets being only $\frac{3}{16}$ in., and there being only a single layer of wire on the armature surface, both the coils and the core are in close proximity to the field-magnets, and hence the mag-

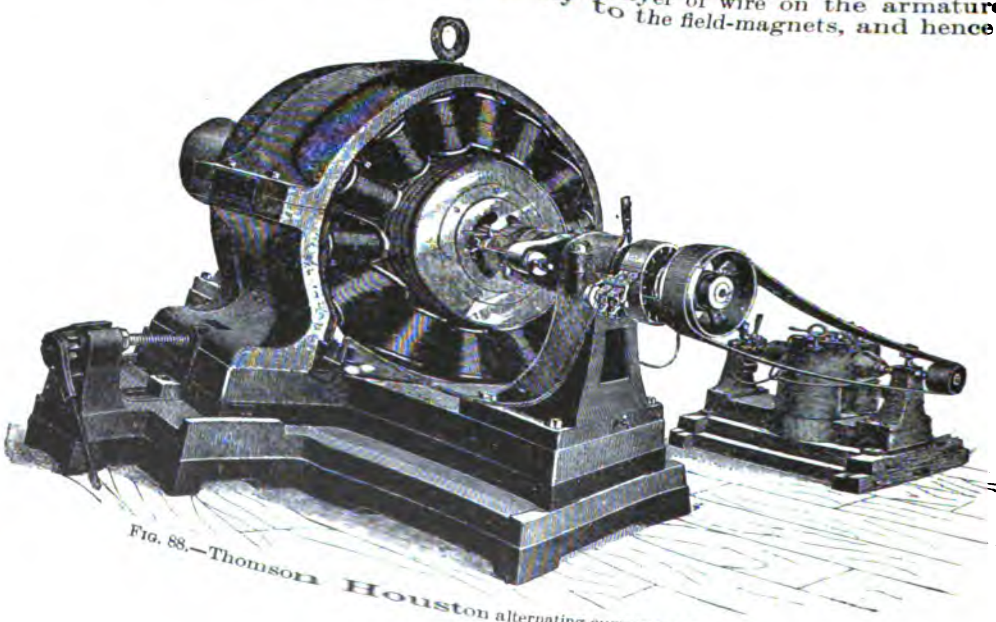


FIG. 88.—Thomson Houston alternating current dynamo.

armature, the upper half of the field-casting can be readily removed, leaving the parts easily accessible. For the purpose of energizing the field-magnets the dynamos are furnished with small exciting dynamos of the direct-current type. It has been found desirable in some special cases to make the smaller sizes of alternating-current dynamos self-exciting, and to this end the armatures are wound with an extra or special coil for furnishing current to energize the fields. The exciter is usually placed as shown in Fig. 88, behind the alternating dynamo, driven by a belt from a small pulley attached to the armature-shaft. One exciter is usually employed with each alternating-current dynamo, but when several dynamos are operated in the same station it is often found more convenient to employ exciters, any one of which is of sufficient capacity for all the machines. By this arrangement an accident to one exciter need not affect the general service.

The accompanying diagram (Fig. 90) and table give the various dimensions, weights, capacity, etc., of these machines:

CLASS.	A, 18.	A, 35.	A, 70.
Weight	*2,100	*3,570	*8,270
Weight of base	150	615	1,245
Material of base	Wood.	Iron.	Iron.
[illegible]d	1,500	1,500	1,070
[illegible]	300	650	1,300
[illegible]power to drive	30	65	130
[illegible]	18,000	35,000	70,000
[illegible]	10	10	14
[illegible]	44	47¼	61¼
[illegible]	23¼	21¼	2[illegible]⅛

CLASS.	A, 18.	A, 35.	A, 70.
C	48¼	67	85
D	13	13	18
E	6	10	13
F	1$\frac{11}{16}$	2¾	3$\frac{7}{16}$
G	24½	23¾	32¼
H	43¼	55¾	73¼
I	42	47	61¼
K	48	67	86
L		+41⅝	+58
M	..	+31¼	+39¼

Ganz & Co.'s Alternating-Current Dynamo.—A type of alternating-current dynamo very largely employed in Europe is that built by Messrs. Ganz & Co., of Buda-Pesth, Hungary. In its early form the Ganz alternator had a star-shaped field-magnet of non-laminated iron revolving within a cylindrical armature, the core of which was composed of thin ring-shaped iron plates held in a frame. The armature-coils were flat bobbins laid upon the inner surface of the armature-core side by side, with insulated filling-in pieces interposed. The magnetic resistance of the interpolar spaces was in this arrangement necessarily high, and in the later machines this difficulty has been overcome by employing an armature-core with a series of internal Pacinotti projections. These projections form the cores of the armature-bobbins, and to avoid the heating of the pole-pieces, the field-magnets are now built up of U-shaped iron plates *F*, as shown in Fig. 91. These plates are laid upon each other, and arranged round the spindle so as to form a star, alternate layers being arranged to break joint, as shown by the dotted lines in the illustration. The plates are fastened together by insulated bolts *B*, and the exciting coils are wound upon separate formers, slipped over the magnet-cores, and held in position by bobbin-holders and screws strong enough to resist the action of centrifugal force. The armature-core, which formerly was continuous, is in the new machines subdivided into a number of T-shaped sections, the central stem of the T forming the Pacinotti projection *A*. These sections are so arranged that each with its armature-bobbin can be removed without disturbing the rest of the machine. The illustration also shows the construction of the armature-sections, and the manner of supporting them. The frame of the machine consists of two ring-shaped castings held together by strong bolts, and, in addition, there are iron traversers to which the segments are bolted. In the figure, the section at I is taken close to one of the cast-iron rings, showing the internal flange to which the traversers are bolted. The section at II is taken at some intermediate point, showing the traversers and the plates of the armature-core; and the series at III is taken at another intermediate point, showing the method by which the armature-core is

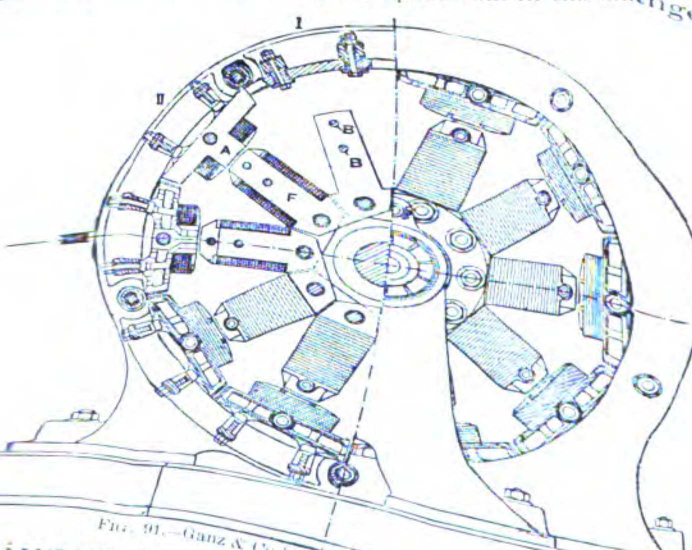


Fig. 91.—Ganz & Co.'s alternating-current dynamo.

* Without base.

+ Approximate.

revolutions per min., and has a peripheral speed of 4,800 ft. per min. The diameter of the armature-shaft is 4½ in. It will be noted that the pulley is placed between two bearings and that the armature is overhung.

Machines of this type are now in course of construction (August, 1891) capable of furnishing current for 200,000 lamps. They will be installed at the Deptford station in London. The following are a few of the details of the Ferranti-Deptford dynamos: The small machines are 12 ft. 6 in. high, 15 ft. over all; the large machines will be 45 ft. high over all, and will weigh 500 tons each. The number of alternations of current will be 4,000 complete cycles per min. (67 per second) in all machines. In the small machine there will be 48 poles, and the speed 168 revolutions per min. The large machines are to be coupled direct, and the speed is 60 revolutions per min. only, the peripheral speed being obtained by the largeness of their diameter. The coils of the dynamos are built up in the same manner as an ordinary dynamo's, each coil generating 125 volts. These are very strongly mounted mechanically, and most carefully insulated, the principle being to bury the conductors in the insulation. The insulation used is sulphur, specially treated, and is so hard that in one case where some metal was found to be mixed with the sulphur it took two days to chip out one coil. The sulphur eats partially into the cast iron and bronze, and makes a thorough joint. Besides this, the surface insulation is carefully arranged to be of porcelain throughout. The electrical efficiency of the armature is very great, two volts being obtained for every foot of copper.

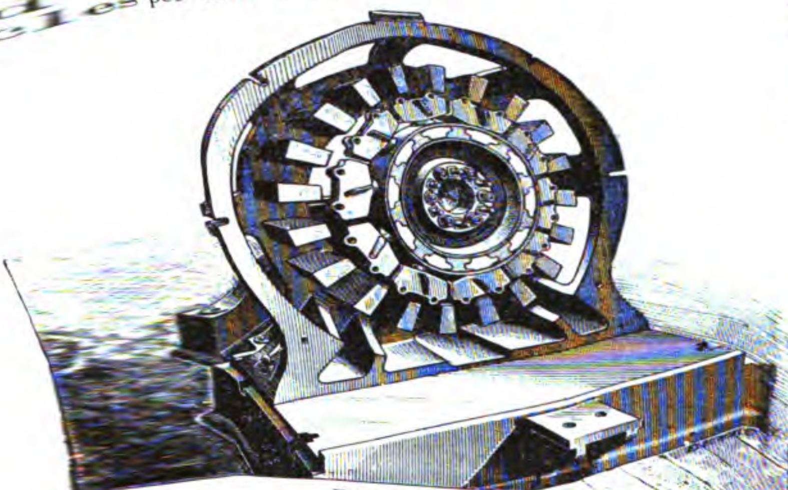


Fig. 94.—Ferranti dynamo.

The Mordey Alternating Dynamo.—This excellent machine was designed by Mr. William M. Mordey for the Brush Electrical Engineering Co. of London, and possesses a number of valuable characteristics. Fig. 95 shows the machine complete, and Fig. 96 the armature, which is stationary, and consists of a number of coils of narrow copper ribbon, wound on cores of non-conducting material. Each coil is bolted between two brackets, the ends of the conductors being brought out through porcelain insulators. The brackets are then bolted to a gun-metal supporting ring, being placed outside of the magnetic field so as to avoid loss from eddy-currents, which are still further reduced by the employment of German silver for the brackets and bolts. The gun-metal supporting ring, which is bolted to the bed-plate of the machine, is in two portions, being divided in a vertical diametrical line. These two parts, after having received the coils, are bolted together and to the bed-plate, the field-magnet being first placed in position. This design provides ample facilities for repairs, as it allows not only of single coils of the armature being quickly removed and replaced, but also renders it easy to take out one half or the whole of the armature.

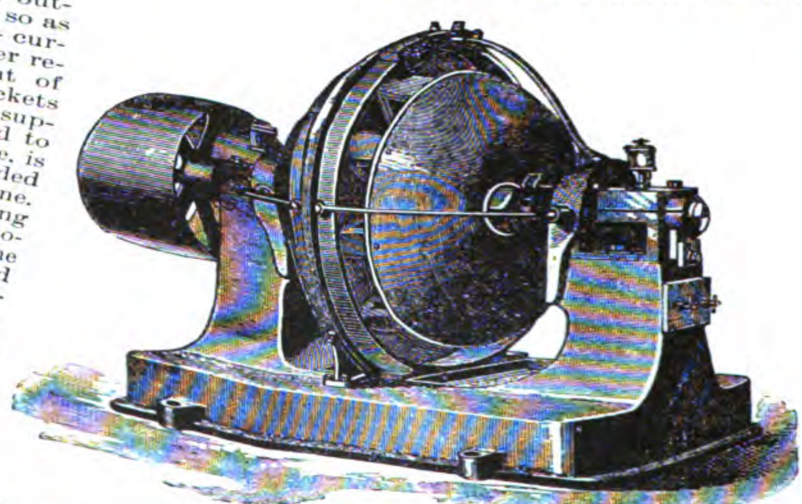


Fig. 95.—Mordey alternating dynamo.

The field-magnet, shown in Fig. 97, consists of a single electro-magnet, built up as follows: A short cylinder of iron, through the axis of which the shaft passes, forms the core of the magnet, and round this core is wound the exciting coil. Against each end of this cylinder is placed a cast-iron piece, of a form which will be best understood from Fig. 97. Each casting has a number of horns or arms which radiate from the shaft

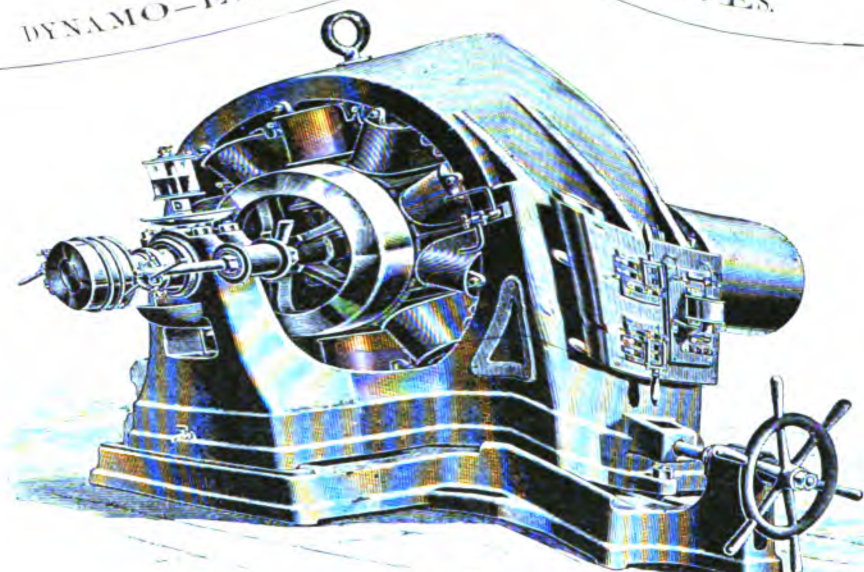


FIG. 98.

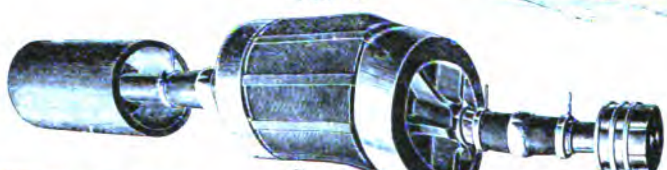


FIG. 99.

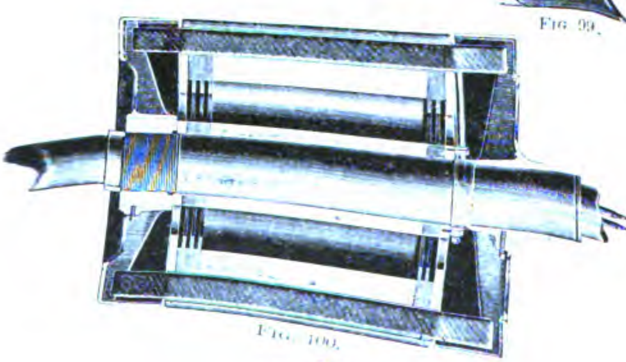


FIG. 100.

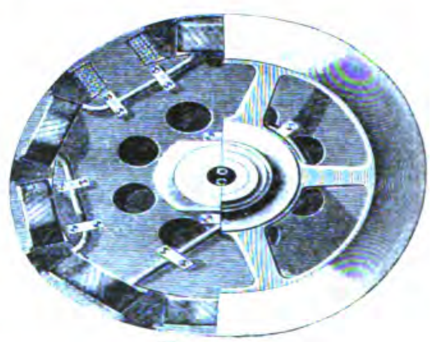


FIG. 101.

FIG. 102.

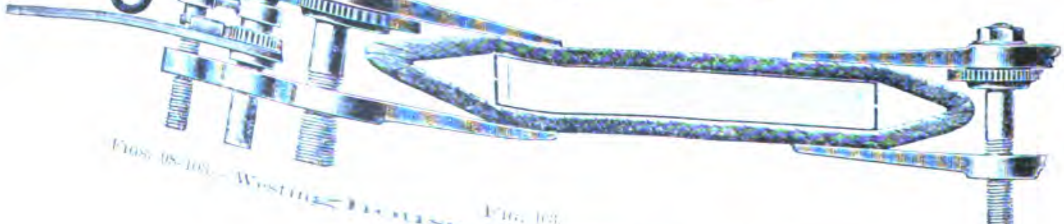


FIG. 103.

FIGS. 98-103.—Westinghouse alternating-current arc-light dynamo.

normal size—i. e., 50 kilowatts—has 32 coils wound, and mounted on 32 cores (radial), which are composed of plates of thin, very soft charcoal-iron, magnetically insulated one from the other. Sixteen of these coils represent the field-magnets of the dynamo, while the remaining 16 intermediate ones correspond to the armature-bobbins of other machines. The cores and poles of both field-magnets and armature-bobbins are arranged radially, surrounding the only moving part of the dynamo, which is called the "inductor-wheel" (Fig. 105), which is the rotating part of this dynamo. It consists of 16 masses of laminated soft charcoal-iron, called inductor-blocks, also mechanically insulated, which are mounted on the circumference of gun-metal fliers or wings, which in turn are clamped between two steel plates, mounted on a boss keyed on to the main driving-shaft. Each indicator-block is just long enough to be embraced by the poles of one field-magnet and one armature-bobbin. The field-magnets are separately excited. The energy consumed for this purpose does not, as a rule, exceed 2 per cent of the maximum output of the machine. By rotating the soft-iron inductor-blocks before the respective poles of the field-magnets and armature-bobbins, rapid periodic reversals of the polarity of the armature bobbin-poles are effected. This produces alternating currents in the armature-coils. Between the inductor-blocks and the above-mentioned pole-pieces there is only just sufficient clearance to allow of free rotation; consequently the resistance of the magnetic circuit of the air-space is a minimum, while the soft character of the iron in the inductor-blocks and the magnet and armature-cores tends also to make this loss as small as possible, thus producing a very efficient machine at a low speed.

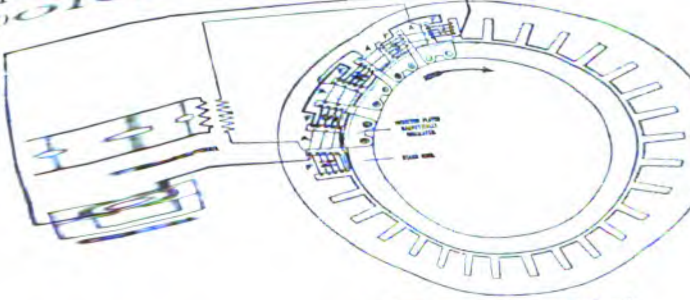


Fig. 105.—Inductor-wheel.

Fig. 106 illustrates the *Kennedy alternator.* The machine very much resembles a transformer in its parts, and is about as simple in construction. The iron field-magnet portions

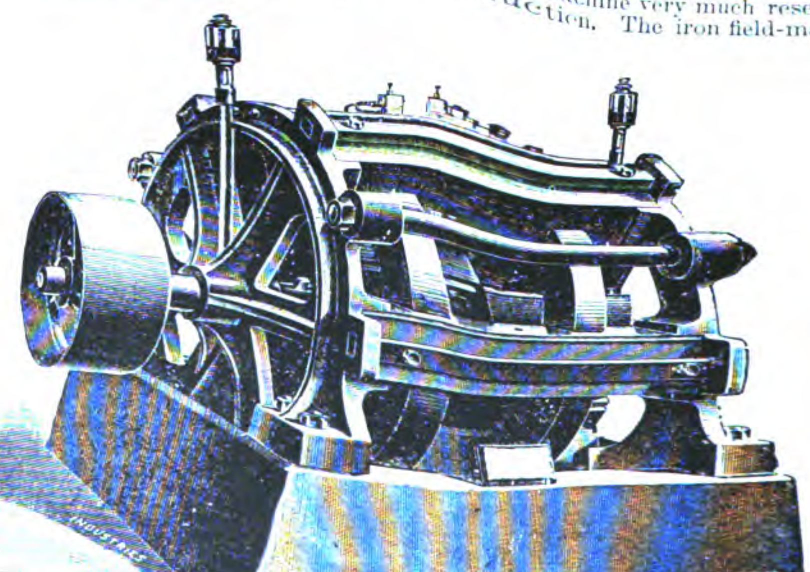


Fig. 106.—Kennedy alternator.

surround the copper coils, which are simple rings of insulated wires; the inductors are carried on gun-metal wheels, and in revolving alternately open and close the magnetic circuit round the copper coils, thus inducing current in them. There is no reversal of magnetism in any part of the operation of the machine; only a simple rising and falling of the magnetic flow without reversal. The iron is made of very ample sections, so that the induction is never high, and never falls to zero. The excitation is constant, but the induction varies with the

ture-conductors are 29 mm. in diameter, and consist of massive bars of copper, insulated inside with asbestos tubes, and buried in holes punched out of the iron close to the internal periphery. Foucault currents, which would attain enormous values in such large copper conductors, if they were arranged in the ordinary way, are by this device avoided; in fact, experiments made with "buried" conductors, 50 mm. in diameter, did not show that power was lost by Foucault currents. This method of arranging the armature-conductors is mechanically strong, and, as it enables asbestos to be used as an insulator, results in an armature which is absolutely incombustible. Moreover, the reduction in the air-space, and the consequent improvement of the magnetic circuit, reduces the exciting current.

Corresponding to the 32 poles of the field-magnet, each circuit of the armature has 32 copper bars, connected in series by transverse pieces. There are therefore, in all, 96 (3 × 32) bars on the armature. The three circuits are joined up to each other in a manner similar to the three circuits of the Thomson-Houston arc-machine. The armature-core is surrounded by a cast-iron frame, and the whole can be moved along the bed-plate for cleaning and other purposes, leaving the field-magnet open to view, as shown in Fig. 109.

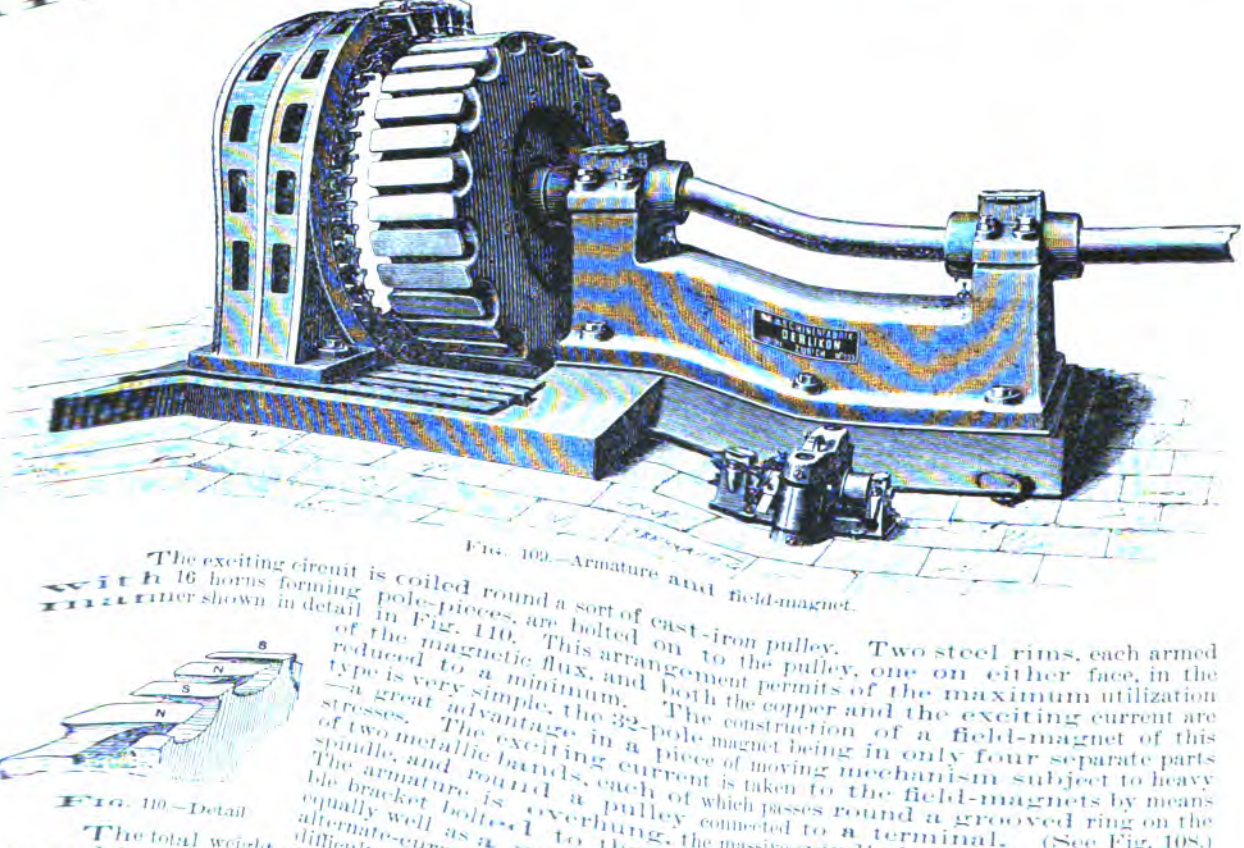


FIG. 109.—Armature and field-magnet.

The exciting circuit is coiled round a sort of cast-iron pulley. Two steel rims, each armed with 16 horns forming pole-pieces, are bolted on to the pulley, one on either face, in the manner shown in detail in Fig. 110. This arrangement permits of the maximum utilization of the magnetic flux, and both the copper and the exciting current are reduced to a minimum. The construction of a field-magnet of this type is very simple, the 32-pole magnet being in only four separate parts —a great advantage in a piece of moving mechanism subject to heavy stresses. The exciting current is taken to the field-magnets by means of two metallic bands, each of which passes round a grooved ring on the spindle, and round a pulley connected to a terminal. (See Fig. 108.) The armature is overhung, the massive spindle being carried on a double bracket bolted to the bed-plate. A machine of this type can work equally well as a synchronizing motor, but it differs from an ordinary alternate-current motor, inasmuch as it can be made to start without difficulty.

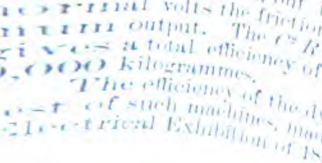


FIG. 110.—Detail

The total weight of copper on the field-magnet is only 300 kilogrammes. To excite the machine so as to give 50 volts on open circuit, only 100 watts are required: that is to say, $\frac{1}{20}$ per cent. of the output. At full load, owing to the reaction of the armature, this amount is slightly increased, but it never exceeds a fraction of 1 per cent. At full speed and with normal volts the friction losses amount to 3,600 watts, about 1·6 to 1·7 per cent of the maximum output. The C^2R loss in the armature-conductors at full load is 3,500 watts. This gives a total efficiency of 96 per cent. The total weight of the machine without bed-plate is 9,000 kilogrammes.

The efficiency of the dynamo is greater than that of any other converter of energy. The test of such machines, made by a committee of the Franklin Institute, in connection with the Electrical Exhibition of 1884, gave the following results:

the brake and regulating the moment of the friction on the disk to the moment of the weights applied to the arm of the brake."

The Richards Absorption Dynamometer, designed by Mr. C. B. Richards, consists of a tank *AB* (Fig. 2) within which two paddle-wheels revolve in oil, thus producing a resistance and a tendency to rotate the whole tank, which is mounted on friction-rollers. This tendency to rotate is measured by the lever-arm acting on a platform scale. By means of a valve the oil in the tank can be allowed to circulate with greater or less freedom; by closing the valve a pressure is brought to bear on the oil in the tank, so that the resistance to the rotation of the inner wheels thus becomes a drag on the driving power; when the maximum resistance is obtained with-

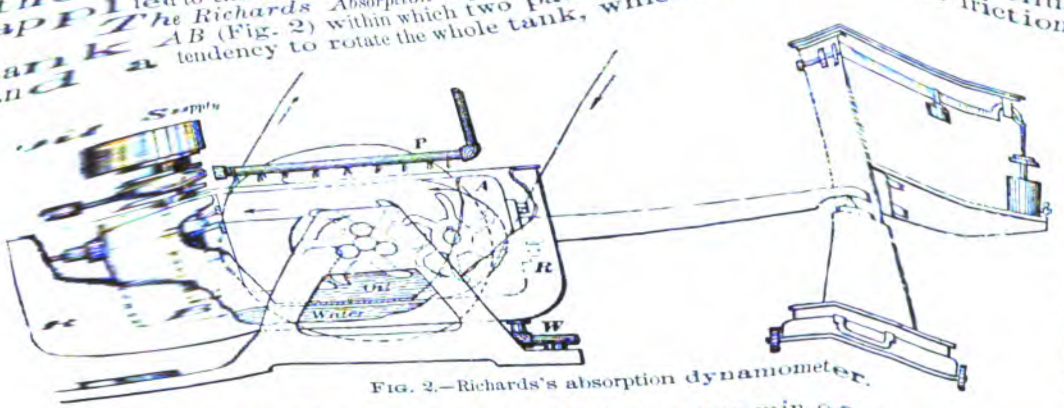


FIG. 2.—Richards's absorption dynamometer.

out decreasing the number of revolutions per min. of the shaft, the force of resistance, measured on the scale-beam, will enable us to calculate the horse-power consumed. In order to prevent any change of temperature in the oil, a constant stream of water is discharged on to the tank through a perforated pipe *P* above it. Beneath the tank proper a metal receiver *R* catches the water, which is then carried off by the waste-pipe *W*, shown at the bottom of the receiver.

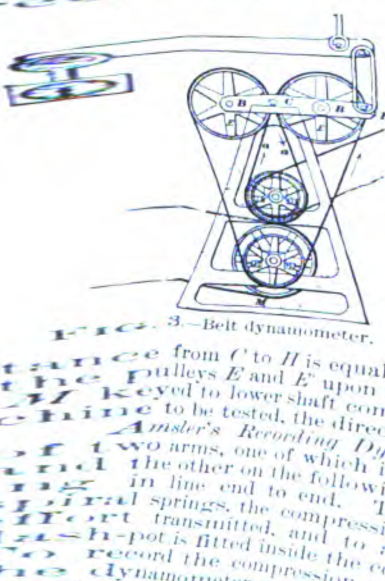


FIG. 3.—Belt dynamometer.

Tatham's Belt Dynamometer is shown in Fig. 3. In this apparatus the difference in tension of the slack and driving sides of the belt is exerted to vibrate a system of lever-arms and scale-beam. The belt from the shaft drives the dynamometer in the direction indicated by the arrows, *a* and *a'* being respectively the tight and loose belts, or rather sides of the belt, driving the pulleys *E* and *E'* on the vibrating frame *B*. The vibrating frame *B* is balanced upon knife-edges at *C*, and is provided with similar knife-edges at *H*, which engage the links of the scale-beam. The distance from *C* to *H* is equal to the effective diameter of the pulleys *E* and *E'* upon the vibrating frame; a pulley *M* keyed to lower shaft communicates motion to the machine to be tested, the direction of belt being as shown.

Amsler's Recording Dynamometer (Fig. 4) consists of two arms, one of which is keyed on the driving-shaft and the other on the following-shaft, the two shafts being in line end to end. The arms are connected by spiral springs, the compression of which measures the effort transmitted, and to avoid violent vibrations a dash-pot is fitted inside the coils of one of the springs. To record the compression of the springs the arm of the dynamometer carries a set of three drums, from the first of which a roll of paper is gradually unwound as the dynamometer revolves, and passing over the second drum is recoiled on the third. A pencil connected with one of the two spiral springs marks the paper as it passes over the second drum. The method adopted for working the drums is peculiar. A weighted lever vibrates on its center through a limited arc as the dynamometer revolves, thus actuating a ratchet, which in turn moves the drums forward step by step; this simple device has been found to act most satisfactorily up to a speed of 150 revolutions per minute.

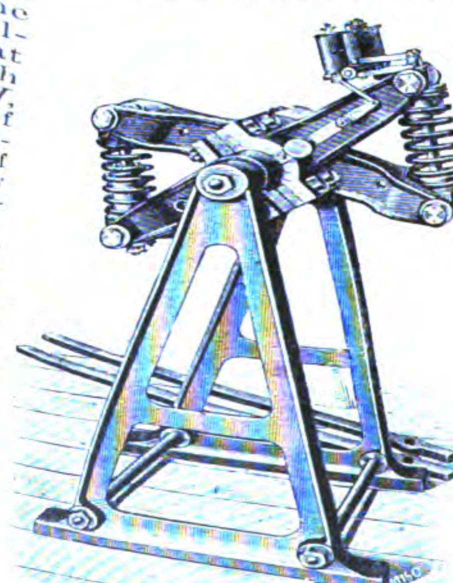


FIG. 4.—Amsler's recording dynamometer.

Ejector: see Harvesting Machines—Grain and Injectors.

EJECTOR, PNEUMATIC. An apparatus for removing sewage used in the so-called Shone system. The sewage from a given district is finally collected into one pipe, shown at the left of Fig. 1, and flows into the ejector at the bottom.

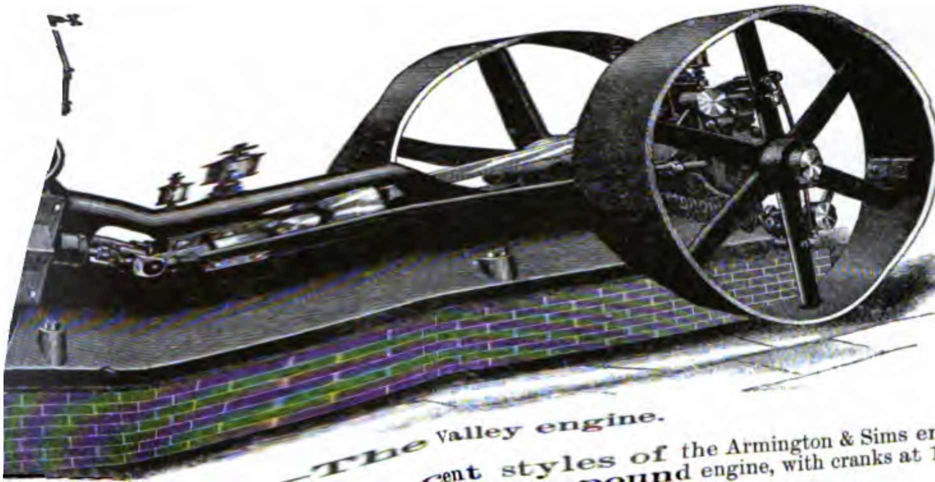


Fig. 37.—The Valley engine.

ms Engine.—Two recent styles of the Armington & Sims engine are
39. The first is a double compound engine, with cranks at 180°, and

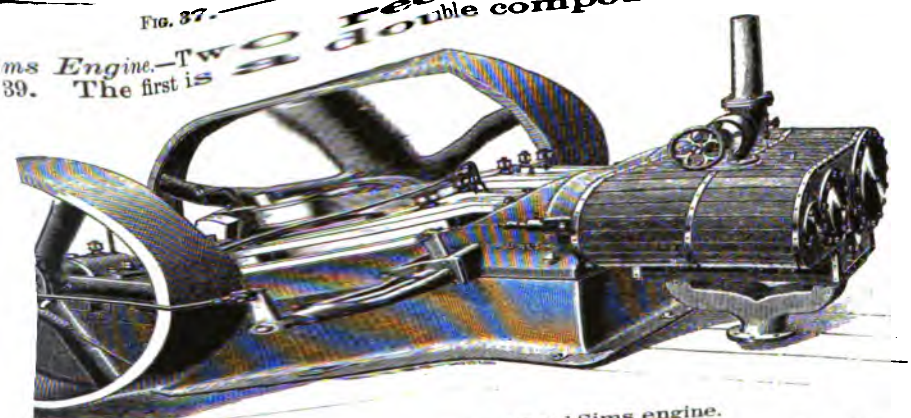


Fig. 38 —The Armington and Sims engine.

a special double engine, especially designed for electric-lighting on
ere saving of space is a prime requirement. Numerous other forms

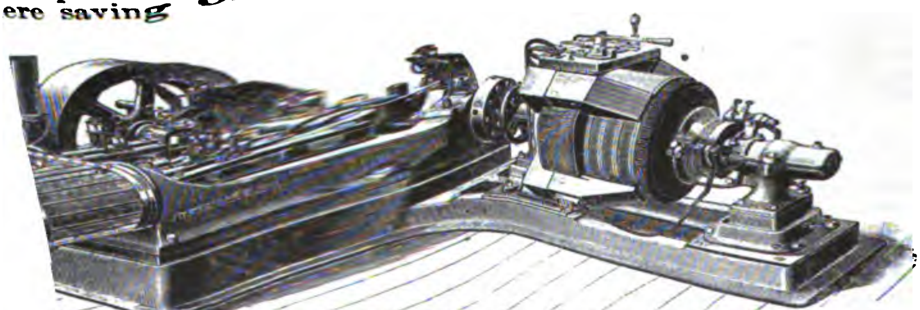


Fig. 39.—The Armington and Sims engine.

e Armington & Sims Co., of Providence, R. I., such as vertical double-
es, etc., all of which are developments from the original engine built

by this company with a single cylinder. A section of the cylinder and valve of the Armington & Sims engine is shown in Fig. 40. The steam-chest, with valve-seat, is in one casting with the cylinder; the valve-chest is inclosed by a cover in the usual manner. It will be seen that the steam-chest is filled with live steam, which surrounds the valve, and that by taking steam in the center of the valve and exhausting at each end, the steam-ports from the cylinder can be very direct, and the waste-room kept small. In the engraving the valve is shown as just taking steam into the cylinder-port at the piston-end; the port in the valve at the other end is also just taking steam from the steam-chest into a port which passes through the valve into the same cylinder-port; this enables steam to be taken very quickly at the commencement of the stroke. The steam is exhausted at each end of the valve by direct passages which quickly free the cylinder. The piston is hollow, fastened by a taper fit to the rod, and furnished with two snap-rings. The valve is a hollow piston-valve, with cast-iron ends, made very light, with a body of steel tubing. It is ground, and perfectly balanced.

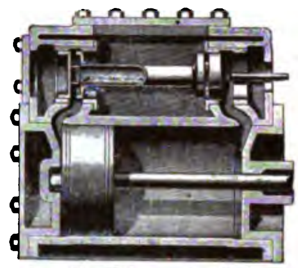


FIG. 40.—Valve and cylinder.

The Harrisburg Tandem-Compound Engine.—The Ide tandem-compound engine, as manufactured by the Foundry and Machine Department, at Harrisburg, Pa., is shown in Fig. 41.

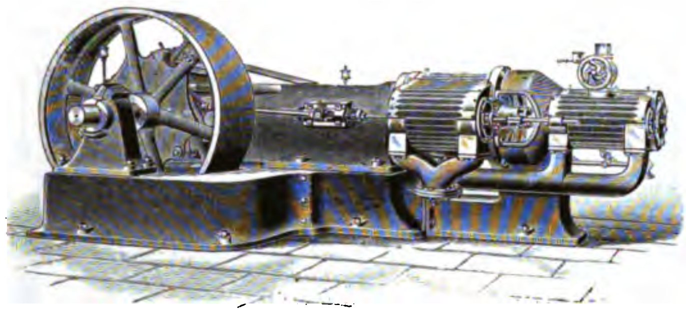


FIG. 41.—The Harrisburg compound engine.

The extra heavy shaft and fly-wheel are supported between the bearings, avoiding the overhang of the fly-wheel, as is the case in the center-crank type. One of the special features in the Harrisburg tandem compound is the method of connecting the high and low pressure cylinders. It admits of moving the low-pressure cylinder head into the connections to examine the low-pressure cylinder and piston without removing the high-pressure cylinder or its steam and exhaust connections. The inability to do this has been one of the greatest objections to the tandem-compound engines as usually built. The manner of supporting the high-pressure cylinder is more substantial than the general practice, avoiding the vibration of cylinders when working under full load.

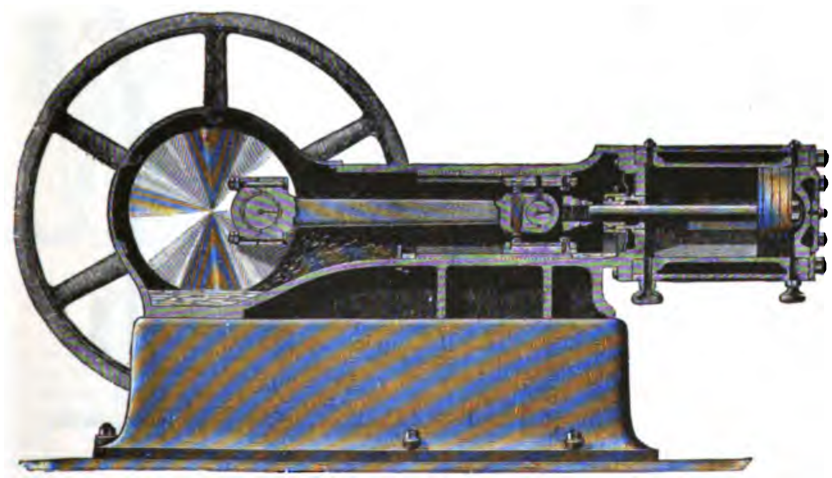
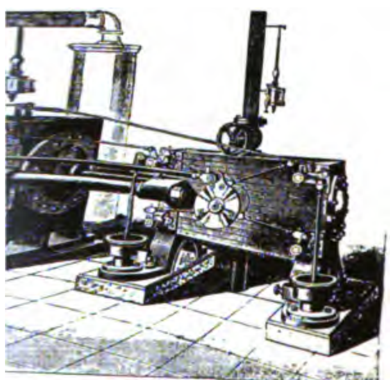


FIG. 42.—The ideal engine.

The Ideal Engine, made also by the same builders, is shown in Figs. 42 and 43. It is a single-cylinder automatic engine, with the peculiar feature of being self-lubricating. The sectional view shows the principle of the automatic oiling device.

ine.

ound class, is shown in perspective in
wing that the steam is taken between



gine.

FIG. 48.—Governor.

—details.

eparate and independent from the
steam-valves are all made so as to

relieve themselves in case of water. Fig. 46 shows the hook-motion valve-gear, Fig. 47 the dash, and Fig. 48 the governor, which has light balls made to run at three times the speed of the engine, and a heavy sliding weight.

The Fishkill-Corliss Engine.—A sectional view of the cylinder of this engine is shown in Fig. 49, and a side view of the valve-motion is shown in Fig. 50. Cité's releasing valve-gear, as applied to this engine, is shown in the accompanying detailed cuts.

Fig. 51 is a front elevation, and Fig. 52 is a plan. These show the valve-gear as it appears when engaged, and in the middle of its travel. Figs. 53, 54, and 55 are rear elevations. Fig. 53 shows the parts in engagement at the moment the valve begins to open; Fig. 54 shows the position of the parts immediately after the valve has been released, and Fig. 55 illustrates the action of the stop-motion.

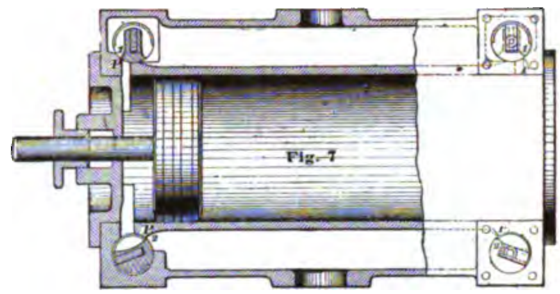


FIG. 49.—Fishkill-Corliss engine—cylinder.

In all the figures *A* represents the valve-stem and *B* the valve-lever, which is secured to the end of the valve-stem by a feather and set-screw. *C C'* is a double crank, which vibrates loosely on a sleeve around the valve-stem, and is connected by an adjustable link-rod to the wrist-plate, from which it receives its motion. The end of the arm *C* carries a small rock-shaft *D*, which has a hook *E* fastened on one end. This hook is provided with a hardened steel catch-plate *b*, which engages a similar plate *c* fastened on the end of the valve-lever *B*, and the hook is kept in place by a light spring *f*. On the end of the rock-shaft *D*, opposite the hook *E*, is fixed a forked crank *F* having a pin *h* on which is mounted a sliding-block *s*, and the outside of block *s* is fitted to move in a slot *i* of a link *G*. The link is mounted at and vibrates about a point *j* in one arm of a bell-crank *H*, and the bell-crank oscillates upon a sleeve around the valve-stem. The other arm of the bell-crank *H* is connected by an adjustable rod *z* to the governor. By referring to Fig. 53, in which the double crank *C C'* is moved by the wrist-plate in the direction indicated by the arrow, and following the motion of the inner end of the block *s*, and also of the inner end of the slot *i*, it will be seen that these points will come together when the curved dotted lines 2 and 3 cross each other, and as the movement continues the block *s* will be pushed farther from the center of the valve-stem, and when the center line of the link shall be coincident with radial line 1, as shown in Fig. 54, the block will have been pushed so far outward that it will have slightly turned the small rock-shaft *D*, and moved the hook *E* enough to release the valve-lever *B*. Then the dash-pot will act and close the valve.

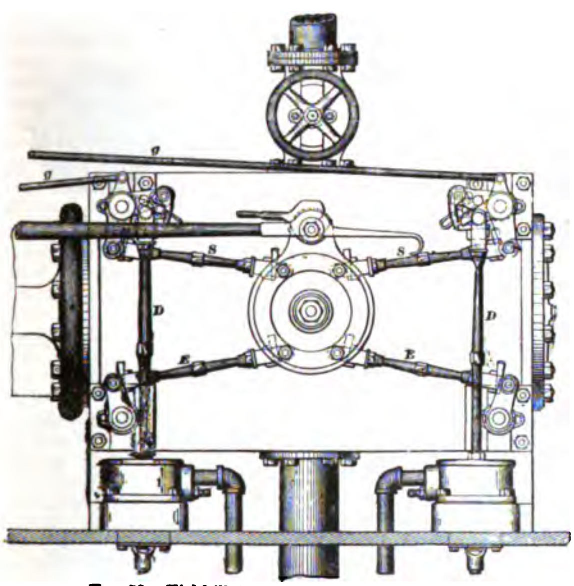
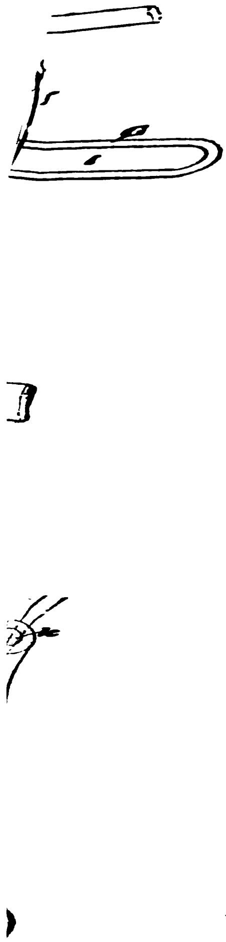


FIG. 50.—Fishkill-Corliss engine—valve-motion.

At this moment of release, effected by the toggle-like action of the link, the pressure on the bell-crank *H*, caused by the liberation, will be exerted in a radial line from the center of the slot through the point *j* to the center of the valve-stem or the stand which supports it, and during the entire movement of the hook *E* there will be no appreciable strain to turn the bell-crank *H*, and consequently there will be no strain to disturb the normal action of the governor. As the position of the bell-crank *H* is controlled by the governor, any change in the height of the governor will cause a change in the position of the point *j*, and a corresponding change in the time of release. The action of the automatic safety-stop motion is illustrated by Figs. 53 and 55. Fig. 53 shows the position of the various parts when the engine is at its lowest normal speed, and the hook *E* is at the point of engagement with the valve-lever *B*. The lower side of the link *G* is provided with an adjustable embossment *w*, which, in the position shown, is just clear from the hub of the bell-crank *H*. Now, should the governor-

ier cause the governor-balls should fall below this point, the
he direction indicated by the arrow in Fig. 55, the emboss-



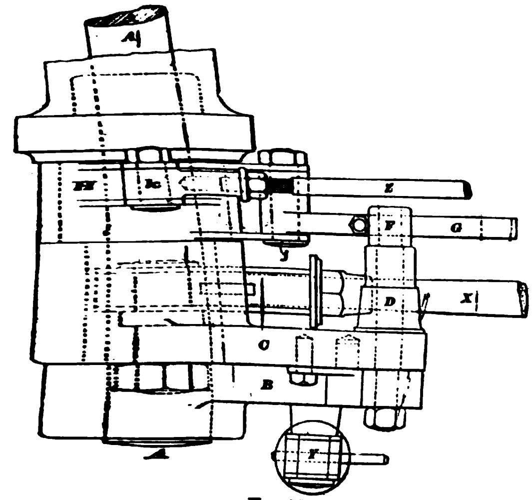


FIG. 52.—Plan.

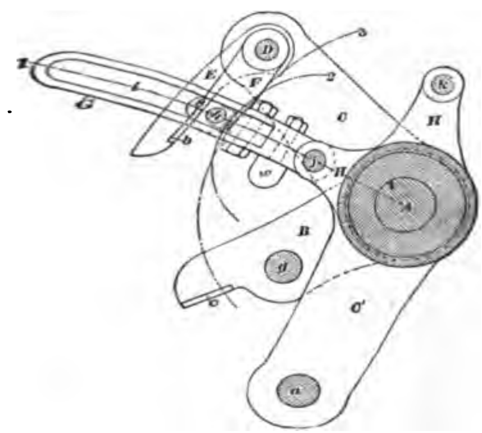


FIG. 54.—Valve released.

ie hub of the bell-
of the bell-crank
as a fulcrum, and
se the pin h in the
r from the center
e hook E outward
the valve-lever B,
n connection with
n the governor-
on of the stop-mo-
n at any time
ative the engine can
d the
vay- engine illus-
the been provided
e steam-chest and
st exhaust-chest
he al Corliss en-
onsist-plates for
wrist-plate, which
ist- its movement from a fixed eccentric upon the
ri and compression may be adjusted without interfer-
se

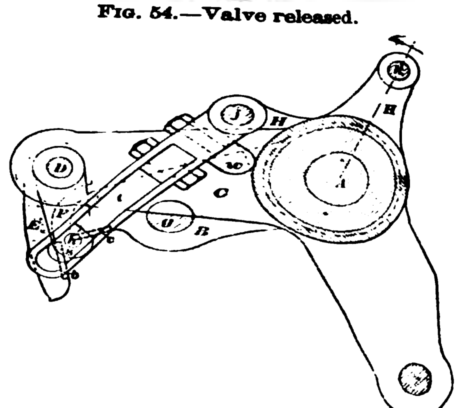


FIG. 55.—Stop-motion.

FIGS. 51-55.—Cité's releasing valve-gear.

ing with the functions of the steam-valve, and, once determined, are positive and fixed. The eccentric, which determines the movement of the steam-valves, is operated by a shaft-governor in such a manner as to open the valves more or less according to the amount of steam required, varying the point of cut-off, while the amount of lead remains practically constant for all loads and pressures. The point of cut-off being varied by the greater or less movement of the wrist-plate instead of by means of a detachable motion, and the valves being closed by a

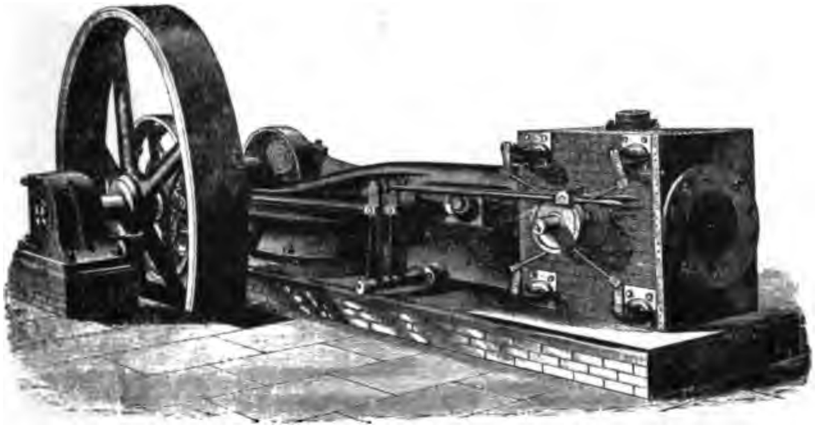


FIG. 56.—The Payne-Corliss engine.

positive connection with the wrist-plate instead of by dash-pots, high rates of rotation and the advantages of the high-speed engine, combined with a distribution of steam to which the economy of the 4-valve engine is due, are rendered possible, inasmuch as the engine is not limited by the inability of the detachable devices to act at high rotative speeds.

The Westinghouse Engine.—The Westinghouse engine is the leading engine of a new type which has recently come into extensive use, the principal characteristics of which are (1) two or more vertical single-acting cylinders, and (2) automatic lubrication by means of a closed chamber surrounding the crank-shaft, containing oil or oil and water. This type of engines was originally built with two cylinders of the same size, with cranks at 180°. Large sizes are built as a compound engine, with one cylinder larger than the other. Engines on the same general principle, but with three cylinders and triple expansion, with three cranks at 120°, have been brought out by other makers. Among the advantages claimed for this type of engine are, that, on account of its being single-acting, the pressure of the piston and of the connecting-rods on the wrist and crank pins is always in one direction, viz., downward, and consequently, no matter how much the bearings are worn, there is no lost motion in them. On this account, the engine, if properly designed, may be rnn at a very high speed, and is therefore economical of room and weight, and saves the gearing for transmission of power to the line-shafting machine or dynamo, necessary with slow-speed engines.

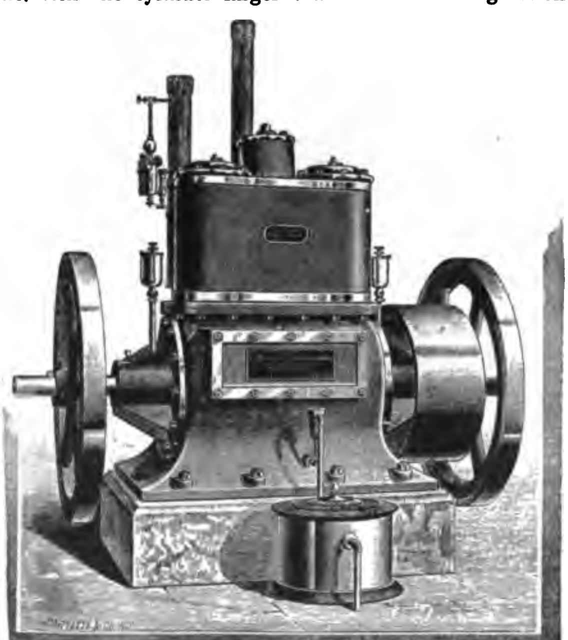


FIG. 57.—The Westinghouse engine.

Fig. 57 shows a front view, and Figs. 58 and 59 sectional views, of the Westinghouse "standard" or non-compound engine as built in sizes from 15 to 250 horse-power. The following is a description of the details: The cylinders A A are cast in one piece with the valve-chamber B, and are bolted to the top of the bed or crank-case C. The cylinder-heads a a cover the upper ends of the cylinders only, the lower ends being uncovered and opening directly into the chamber of the crank-

·m, double-walled at the top to prevent con-
hardened steel wrist-pins *b b*. They are each
; *F' F* are made of forged steel. The cranks
ıll of steel, and may be removed by taking off
;s are in the form of removable shells *d d*, lined

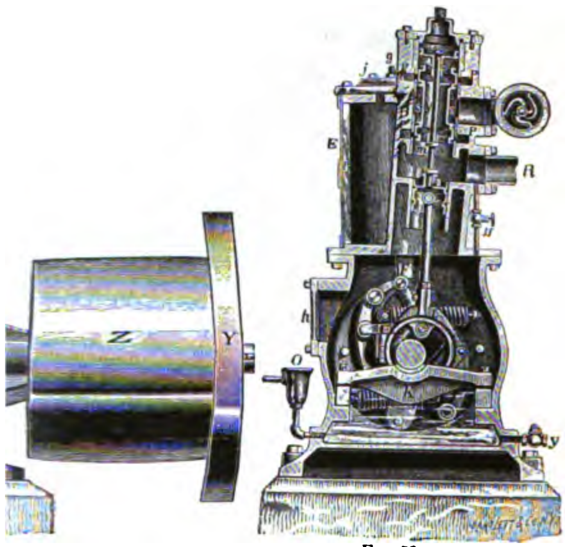


FIG. 59.

e engine—sectional views.

› these bearings are split for the sake of con-
:. They are slipped into the crank-case head
g *t*, which is of an arbitrary thickness depend-
k-case. A chamber is formed in the outer end
ing with the shaft, is the ring-wiper *w*, which takes up the oil as it works past the bearings, and returns it through the hollow rib *e* into the crank-case *C*. Oil is fed to the engine from the sight-feed cups *l l* on the main bearings; this renders all other lubrication unnecessary, and keeps the engine clean. A siphon overflow, with a funnel-head *O*, prevents any accumulation of water from rising above the level of the bottom of the shaft, and thus prevents the escape of oil. This overflow may be piped off at the hole in the funnel-head to an oil-separator, shown in Fig. 59, from which it can be skimmed and restored to the crank-case. An adjustable center-bearing *K* bridges the crank-case, and receives the thrust of the pistons. The bonnet *h* is removed, to give access to the cranks. The valve *V* is a piston-valve, packed with two rings in each head. The valve-seat is a removable bushing, in which the ports are cut to an exact register, and which is then forced into its shoulders. Each valve is provided with a back-pressure piston, which

e.

prevents the balance of the governor from being disturbed when the engine exhausts against back-pressure. The valve-guide J serves also in lieu of a stuffing-box against the exhaust steam contained in the passage above it. The valve-guide as well as the valve and both pistons are packed with simple sprung rings of cast iron. The valve-stem m is keyed fast to the guide, and grips the valve without binding between the nut at the upper end and the collar at the lower end, as shown. The band-wheel is a combination-pulley Z and fly-wheel Y, cast together, so that the pulley overhangs the main bearing, throwing the line of belt-strain well toward the center of the bearing, and taking the spring off from the shaft.

The automatic governor is located on the shaft, between the cranks, and actuates the valve direct without rock-shafts or other mechanism.

The Westinghouse Compound Engine is similar in general characteristics to the non-compound engine above described. It is shown in section in Fig. 60. One cylinder is enlarged to practically three times the area of the other. The valve-chest is across the top of the cylinders, and is in one piece, the various steam-passages being chambered in it. The valve-seat is in the form of a bush, in which the ports are cut to an exact register. This bushing is reamed out and forced steam-tight into its bored seat.

FIG. 61.—Westinghouse shaft-governor.

The valve-chest also contains a small by-pass valve controlling a cored passage, by which live steam can be admitted to the low-pressure cylinder, to turn the engine over its center when starting. The steam and exhaust connections, are on the side of the valve-chest toward the back of the engine. The valve is actuated by a single eccentric controlled by a shaft-governor, shown in Fig. 61. It is inclosed in a case which is filled with oil when the engine is first set up, and requires no further attention for an indefinite period. The eccentric alone is outside of the governor-case, being carried on a shaft running through a sleeve, and bearing against stops when at full throw.

The economy of steam of the Westinghouse engines is shown in the following figures published by the builders. The first table gives the results of three tests of a non-compound 45 horse-power engine, under three conditions of loading:

Average boiler-pressure....lbs.	91·7	92·5	92·1
" mean effective pressure.... "	39·49	30·76	22·33
" revolutions per min....	352·2	353·9	356·7
" indicated horse-power....h.-p.	44·81	35·08	25·66
Feed-water consumed per indicated horse-power per hour....lbs.	32·60	32·99	36·27

The next table shows the results of tests made in 1888 of a compound engine 14 and 24 in. cylinder, 14-in. stroke, under varying loads. The engine was unjacketed. The steam was measured after being condensed in a surface-condenser, which was less open to the atmosphere in the non-condensing tests. The steam consumption is given in pounds per indicated horse-power per hour:

NON-CONDENSING, BOILER-PRESSURES.				HORSE-POWERS.	CONDENSING, BOILER-PRESSURES.			
60 lbs.	80 lbs.	100 lbs.	120 lbs.		120 lbs.	100 lbs.	80 lbs.	60 lbs.
Steam consumption.					Steam consumption.			
....	....	....	22·6	210	18·4	....	....	....
....	....	23	21·9	170	18·1	18·8	....	....
....	24·9	23·6	22·2	140	18·2	18·5	20	....
....	25·7	23·9	22·2	115	18·2	18·6	19·6	20·5
26·9	25·2	24·9	22·4	100	18·3	18·6	19·7	20·3
27·7	25·2	25·1	24·6	80	18·3	18·6	19·9	20·1
30·3	28·7	29·4	28·8	50	20·4	20·8	20·7	20·4

The Willans Central-Valve Triple-Expansion Engine, made by Willans & Robinson, Thames-Ditton, England, is shown in section in Fig. 62. The piston-valve is shown at the left of the engine.

The engine is arranged with the high-pressure cylinder above the intermediate cylinder, and with the latter above the low-pressure. In engines which have more than one crank, each crank is surmounted by a complete engine, all the pistons of which are carried by one piston-rod. The rod is of large diameter and is hollow, and the valve for admitting and exhausting the steam from the several cylinders works up and down inside it, in the center of the engine (hence the name "central-valve"). It is driven in the usual way by an eccentric, but since the valve-face (i. e., the inner surface of the hollow rod) moves up and down with the pistons, the source of the valve-motion (i. e., the eccentric) must move up and down

eccentric on the crank-pin, instead
;eam enters and leaves the respective
.mply holes in the hollow rod. These
ernately to steam coming from above,
›d, and to exhaust (also through the
l, according as the corresponding pis-
valve pass below the holes or above
enters at the top, through the gov-
e-valve, shown in section, into the
The top of the hollow rod, though
closed against the steam by the upper-
›f the valve, which works in the part
›les. Steam can therefore enter the
n the holes are in the steam-chest, as
n the high-pressure piston is near the
its travel. On commencing the down-
ppermost valve-piston is just passing
les, and therefore admits steam into
igh-pressure cylinder. It rises again,
ports, when the piston has descended
uarters of its stroke; but the cut-off is
r than this by the holes in the upper
ollow rod, leaving the steam-chest and
igh the gland in the cylinder-cover—
heir supply of steam. It is evident
off may be made to take place at any
roke, merely by drilling the holes high-
the rod; the lower they are the earlier
will they leave the steam-chest. (The
produced by altering the height of the
cylinder-cover.) After cut-off, the
pansively on the high-pressure piston
ay. By the time the piston has reached
its stroke the piston-valve has passed
rts, and a way is opened from above
e below the piston, or first receiver.
p-stroke (effected by the momentum
eel only) the steam is merely trans-
cally without change of volume or
succeeding down-stroke steam passes
he hollow rod again, and out by holes
On the next up-stroke the steam ex-
r; in the next down-stroke it passes
it is transferred into the "exhaust-
re; but it is not until the third revo-
sure cylinder that it is finally expelled
constantly acting upon the valve-pis-
constantly pressed against the eccen-
steam-pistons the case is different.
ring the up-stroke, for there is at that
lower sides of all of them. Special
ntum on the up-stroke, so as to keep
The upward movement of the guide-
, until at the top of the stroke a con-
e of pistons, etc., without shock, and
in. In fact, an air-cushion is substi-

edy, showed a water-consumption of
developing 36·44 horse-power.
ws a pair of rolling-mill engines built
r Mill in Pittsburg, Pa. The engines
y pass of the plate in the rolls. The
h Reynolds' Corliss valve-gear with-
es is controlled by the operator, and
revolutions per min. The reversing-
sm, operated by steam, which is con-
position he has an unobstructed view
or the roll-shaft and engine crank-
ring proper means of taking up wear
is transmitted to the roll-shaft by

lard & Co., Chicago, is shown in Fig.
ct that while steam is made in the

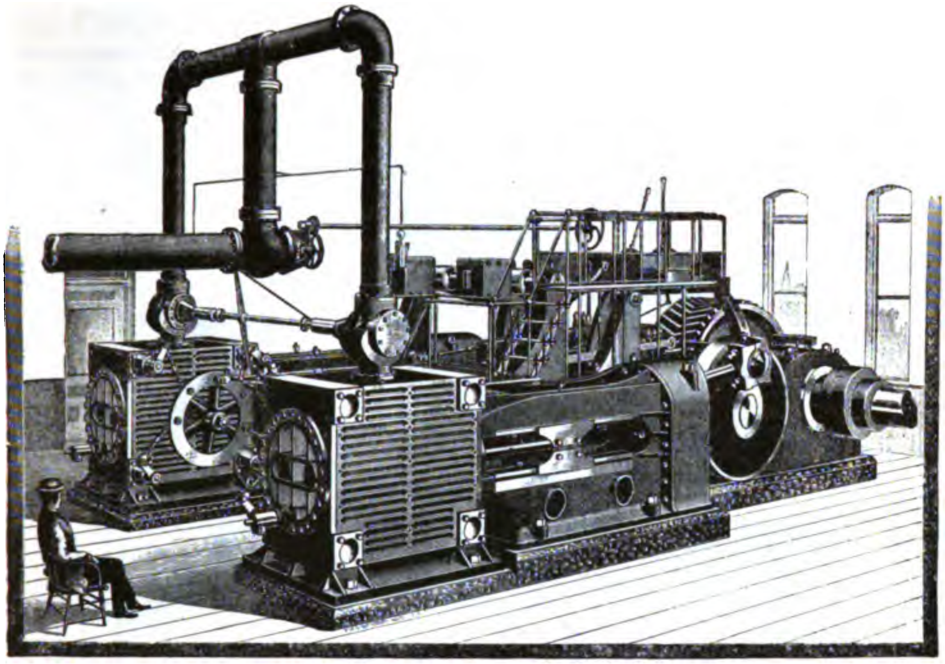


FIG. 63.—Reversing rolling-mill engine.

generator, which is a part of the machine, the only function of the steam is to create, by condensation, a vacuum, which is the motive-power. The engine is double-acting, a vacuum being created alternately at each end of the cylinder. There is no greater than atmospheric pressure in the generator, and there consequently is no danger of explosion. The condensation of the low-pressure steam, by which a vacuum is created, is effected by means of a surface-condenser, which is kept cool by water. Where the engine is to be used in a city or town having public water service, the condenser is placed in the upright iron pocket shown at the back of the engine, and a small stream of water—for the 2-horse-power, ½-in. pipe; for the 4 horse-power, ¾-in. pipe—furnishes an abundant water-supply to keep the condenser cool. The water is admitted at the bottom, and rises to the top, and passes off through an overflow-pipe. Where there is no public water-service, the engine itself operates a small pump, which causes a circulation of water.

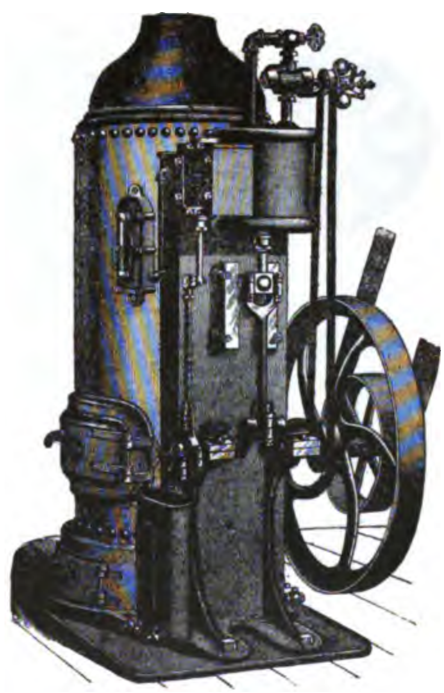


FIG. 64.—The Willard condensing engine.

The cylinder does not require oiling or lubrication, as the low steam used, being very moist, is a sufficient lubricant. The engine requires no attention beyond simply keeping up the fire, and giving the wheel two or three turns when ready to begin operations. There are no exhaust, no steam-gauge, no gauge-cocks, no boiler feed-pump or injector, nor any of these adjuncts of an ordinary steam-boiler. It is practically noiseless, and there is no escape of burned oil or noxious odors. Where power is needed in offices and buildings heated by steam, for running ventilating-fans, printing-presses, or other machinery, the engine may be connected by a pipe with the steam-coil in the room, and run in this way without any generator with the machine; consequently there will be no ashes or dust, and the engine may be started or stopped by opening or closing the valve connecting with the steam-coil.

iiler, made by the Rochester Machine-Tool
l 66.
ıder, single-acting engine, with cranks 180°
roke in length, form their own guides, the

matic safety engine.

pistons, and the steam-rings above and below
ocking type, and is placed on the top of the
ads. The fly-wheel contains the automatic
n to suit the varying loads, by changing the
Lubrication is accomplished by carrying in the crank-case a mixture of oil and water, into which the cranks dip at every revolution.

The boiler is shown in Fig. 66. It is of the sectional type, the water being carried in a series of rings connected by inclined tubes that break joints. The boiler is double-jacketed to prevent loss of heat by radiation. A large dome on top is used to dry the steam. The water-supply is maintained by a pump worked from the main shaft, which forces the water through a coil-heater, where it is subjected to the effects of the exhaust steam before entering the water-leg of the boiler. The supply of water to the feed-pump is regulated by a ball-float in a case attached to the boiler, which, by means of levers, controls the amount delivered at each revolution of the engine, and may be adjusted to maintain the desired level of water in the boiler under the varying loads to which the engine may be subjected. The fuel is kerosene-oil of 110° to 115° fire-test (this grade giving the best results), atomized by a steam-jet, and controlled by an automatic fire-regulator, that reduces or cuts off entirely the supply of
t at which the regulator is adjusted. This fire is
tant supply of steam. The tank containing the
n being as high as or higher than the burner.
ed by the cap of the atomizer, as before stated.
located on the oil-pipe, that shuts off the oil
her by hand or the action of the fire-regulator.
by the Shipman Engine Co., Boston, is shown in
a side view of the connecting-rod are shown in
1 to 6 horse-power is shown in Fig. 69.
-engine, for use either on launches or in houses

where a moderate amount of power is required. It is automatic, so that, when once steam has been generated in the boiler, practically no further attention is required beyond that of open-

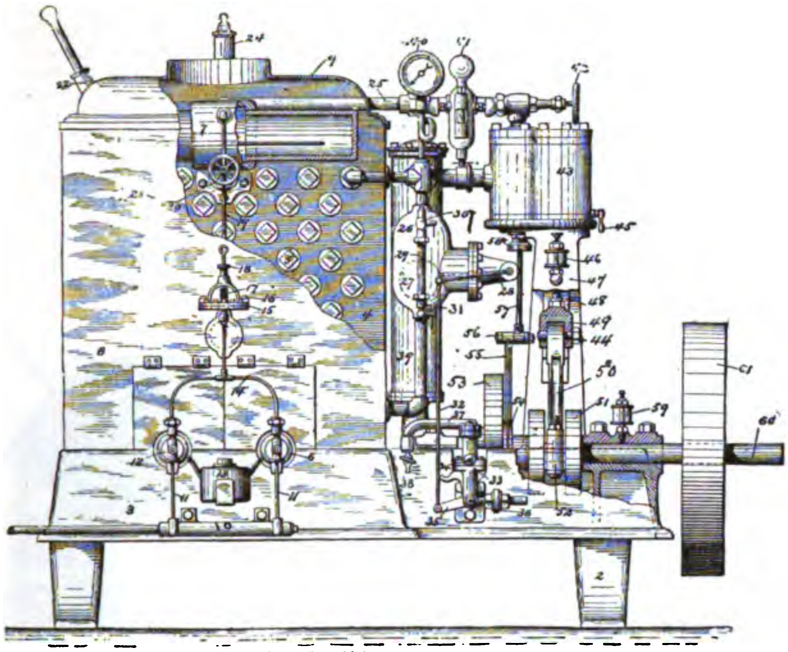


Fig. 67.—The Shipman engine and boiler.

ing and shutting the steam-valve whenever the engine is started or stopped, the fire, speed, and water-feed being so arranged as to attend to themselves. The engine is built upon the same frame as the boiler. This latter is composed of tubes about 18 in. long, which are screwed into a flat, oblong chamber at one end and closed at the other, and is fired externally. Two small aspirators or atomizers, taking steam from the boiler, suck up the petroleum, which is used as fuel, from a chamber below, and drive it into the

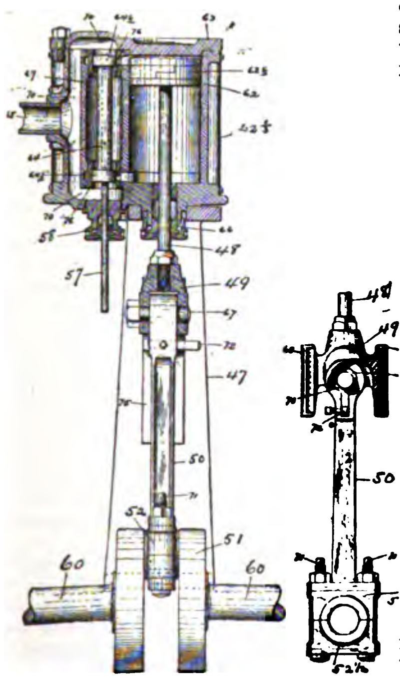


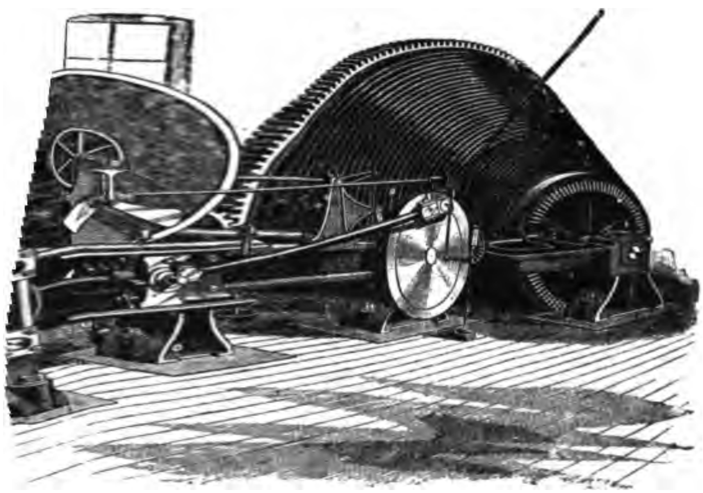
Fig. 68.—The Shipman engine.

Fig. 69.—The Shipman boiler.

furnaces in the form of a fine spray. A couple of torches ignite this spray as it passes inward, and the flames produced by its combustion rush round

ı and petroleum that is used by the atomizers
ı in the steam-pipe that supplies them. This
the one side, and is held down by a spring,
oves upward or downward as the steam exerts
Its movement is conveyed to the valve by
ınt of steam passing at any moment to the
inversely as the pressure in the boiler, and
ı is stored in a tank at any convenient dis-
a pipe having a regulating valve in it. The
y means of a float, connected to a tap in the
d in a chamber, which is joined to the top and
he level of the water. The movement is con-
of levers, to the tap in the suction-pipe, which

ıoisting-engine built by the E. P. Allis Co., of
Reynolds girder-frame Corliss engines. They



e Allis hoisting-engine.

rsing-gear, etc. The conical rope drum is 18 ft. in
ıall end, and 12 ft. 9 in. long. The cylinders are 16
this style are built with different sizes of drums and
erent locations.

ound Engine, made by the Phœnix Iron-Works Co.,
is a two-cylinder compound, both cylinders being
ed independently of each other, so that they are free
, there being no excessive weight or strain upon either
ade in two parts, the lower or sub-base extending the
a hood at the rear end, to which is attached the low-
d bolted to it the same as to a foundation, stands the
bearings, guides, and the overhanging high-pressure
distinctive feature of the engine. It allows each cyl-
tly of the other, and either cylinder is easy of acces-
er. The rod seen passing over the cylinders ties the
struction. The valve mechanism is so arranged that
is under the control of the governor, and varies with
tribution of load and temperatures between the two
can be adjusted by the engineer to suit varying con-
ther by the action of the governor, thus *preventing*
The valves are of the double-piston type, *working*
repairs.

densing Engine.—The full-page engraving repre-
the Shrewsbury Mills, at East Newark, N. J., by
J. The engines are tandem-compound, coupled
pressure cylinders are 20 in. diameter and the low-
The engines run at a speed of 64 revolutions per
linders are steam-jacketed, the former with steam
the exhaust steam from the high-pressure cylinders.

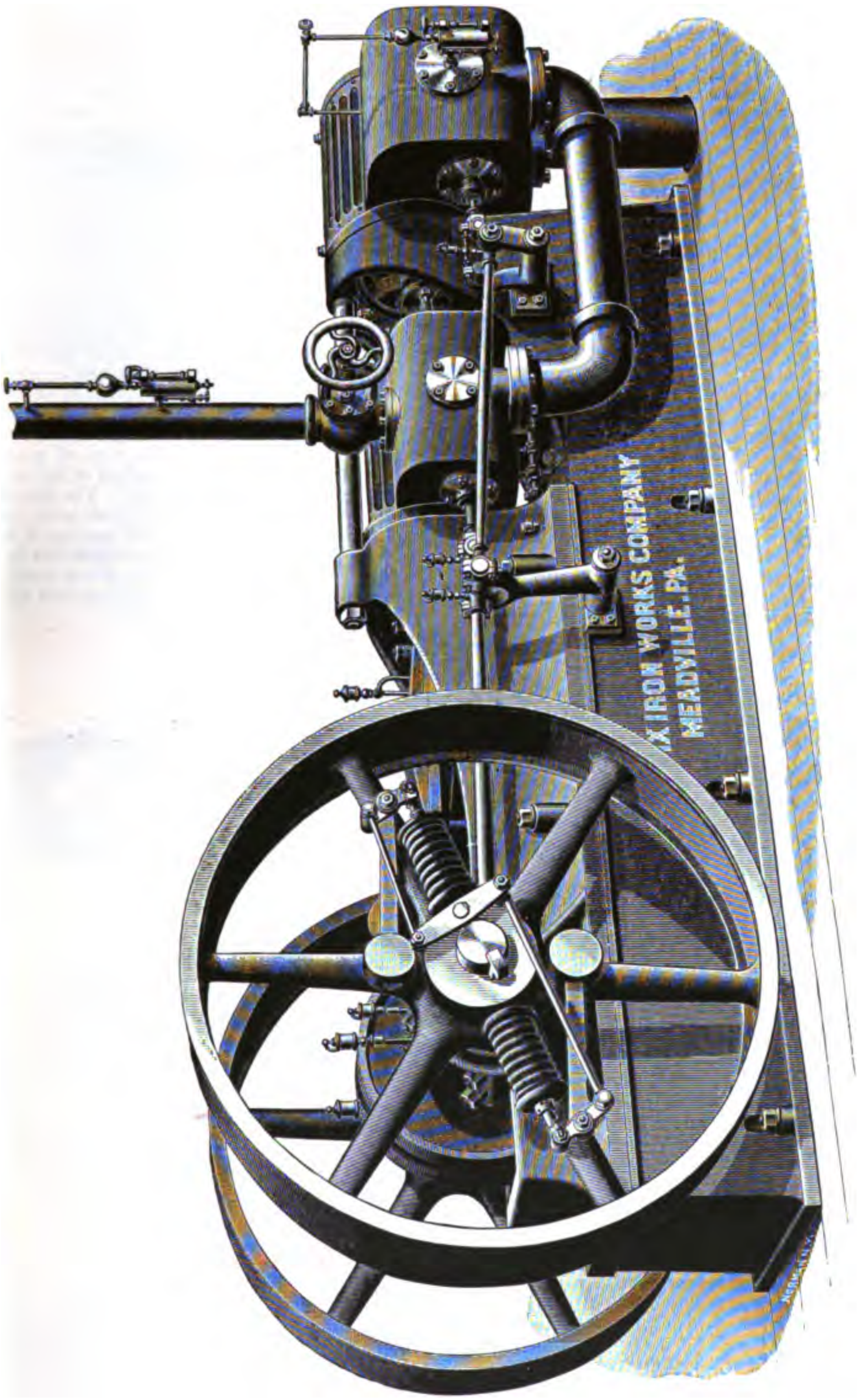


Fig. 71.—The Dick and Church tandem-compound engine.

high-pressure cylinder passes down through the legs to the receiver, the low-pressure cylinder and includes the jacket-space of that cyl- ressure cylinder the exhaust goes through a large rectangular passage is situated midway between the two low-pressure cylinders. A small r of condensation from the jackets to the boilers. But one air-pump driven by a return rod from one of the crank-pins. The main shaft is center or wheel fit, and 13 in. at the journals. The band fly-wheel is up in ten segments. It has a face of 6 ft. 2 in., turned for two 28-in. t. The weight of the fly-wheel is 73,000 lbs. The valve-gear is of the ifications that have been introduced by the Watts-Campbell Co. The means of a small fly-ball governor, running at very moderate speed admission by eight steam-valves with great precision, without the use of a dash-pot or equivalent attachment to prevent fluctuation. This absence of shock to the governor is mainly due to the action of the releasing gear.

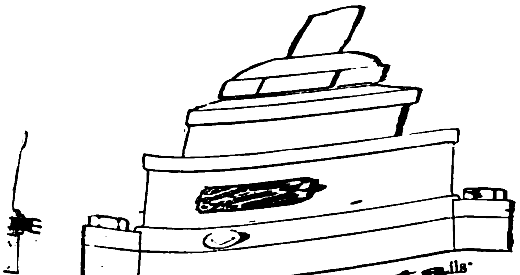


Fig. 72 shows the dash-pot used in the Watts-Campbell Corliss engines. The vacuum which serves to close the valve is maintained in the chamber above the central post. As the piston descends, closing the steam-valve, any small quantity of air that may have found its way into this chamber is displaced through the automatic valve shown in the top of post. The cushioning is accomplished in the annular chamber at the bottom. The piston in falling is first partially obstructed in

condensing engine details.

art of the annular chamber; then, as it passes this tapered portion, it is sted, the only escape for the imprisoned air being such as is provided by By means of this screw any desired adjustment of cushion can be made, preventing the parts from striking metal to metal while making such ad- ime while in operation.

piston packing used in these en- Fig. 73. The weight rests upon which the piston and follower are When, by wear of the bottom of l of the cylinder, the piston gets t can be accurately centered by ting screws. This is considered ential in a horizontal engine, in avity, the bottom of piston and jected to somewhat the most wear. ries the weight of the piston, and and follower from the wear. By the ethod of turning the center ring g part is made to exactly fit the ler, the ring being turned out of quisite clearance. This gives full m the start. The packing con- ngs, one at either edge of the cen- turned somewhat larger than the then cut and halved together at in place they keep in easy contact without undue friction, compen- heir own elasticity. Light springs own, which assist in keeping the th the cylinder until they are worn r is connected with a cross-shaft ingle rods extend to the releasing four cylinders, doing away with uble rods usually employed. In the connecting rods are six cranks iston-rods have two different diam- th, the difference being sufficient to for the low-pressure pistons. These n place by a key. By disconnecting the rod at the cross-head and moving iston back into the space between the two cylinders the key can be removed: he rod forward, the piston can be removed. A noticeable feature in these enings which hold the bed-plates to the pillow-block. In addition to the s are cast in the front side of the pillow block and in the front side of the pillow-block, and a wrought-iron link is shrunk over the parts inclosed by g the pillow-block and frame firmly together.

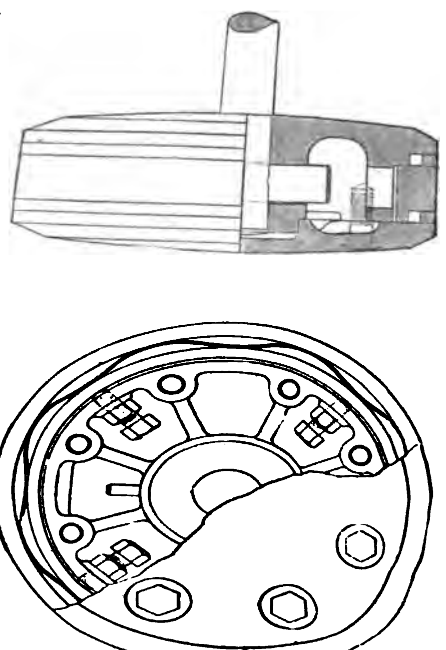


FIG. 73.

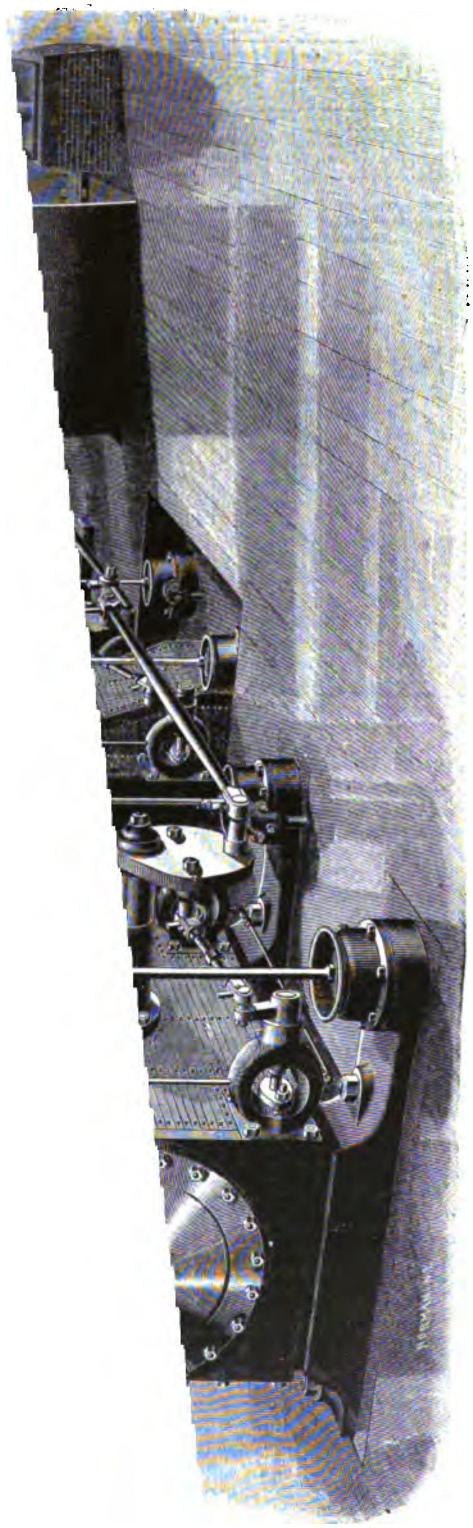


Fig. 74.—The Frick-Corliss engine.

pbell Company's Compound-Tandem Engines 3d, 7 A. M., and ending May 7th, 7 A. M.

Coal used per hour, running time.	Indicated horse-power.	Coal per hour per 1 horse-power.	Revolutions per minute.
476·19	273·09	1·74	64
523·81	295·48	1·77	64
542·86	311·74	1·74	64
513·62	309·81	1·65	64
514·12	297·53	1·73	....

for banking fires; no allowance for ashes.

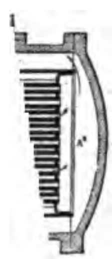
engine.

The table above shows the result of a recent test of a pair of these engines, guaranteed to develop 700 indicated horse-power per hour. Upon starting the engines it was found that it would not, at least for some time, be practicable to load them to more than about 300 horse-power; it was then concluded to disconnect one of the pair and test the other, the builders of the engines waiving the right to steam of 110 lbs. pressure, and using but 80 lbs.; two boilers only were used. While the engine was run only through the ordinary working hours—10¼—all the coal used during the 24 hours was charged against it; this included coal for banking fires, getting up steam in the morning, etc. The test was continued for 4 days—96 hours—a large number of diagrams being taken from which to compute the power.

The Frick-Corliss Engine.—Fig. 74 (from *Cassier's Magazine*) represents a tandem-compound Corliss engine built by the Frick Co., engineers, Waynesboro, Pa. The valve-gear is of the Corliss type, with constant lever-disengaging motion. One governor controls steam-valves on both high and low pressure cylinders. The wrist-plate motion is driven by two eccentrics, making independent actuation for steam and exhaust valves, and is known as the *long-range* cut-off. The engine is designed for electric railway and cable work where the variation of the loads is very great. The low-pressure cylinder is 44 in. diameter, high-pressure 30 in. diameter, fly-wheel 25 ft. diameter, 6 ft. face, weight 50 tons. Connection is had

ɐssure cylinders by means of a receiver-pipe, which connects
the side of the low-pressure cylinder leading to the steam-
ʰas a nominal capacity of 750 horse-power.
und-Engine, made by the Wells Engine Co., of New York, is
for this engine that it has a natural balance in weight of the
ıs, at all angles of the cranks and at all speeds; also a balance
ıt being attached to opposite sides of the crank-shaft moving
ne plane), the thrust of one is perfectly counteracted by that
simultaneously to the bottom of the high-pressure and to the
and *vice versa*. The force on one cylinder-head is counter-
er. Hence there can be no strains transmitted to the frame,
boxes. The ascending steam force on the small piston is
rce on the large piston, which transfers the fulcrum from
ɔoncentrating the whole force in the shaft for useful effect.
are three connecting-rods, one transmitting the pressure
ıd the other two connecting with the two piston-rods of

—F. W. Dean, of Cambridge, Mass., has recently invented
compound engines for the purpose of superheating the
re cylinder before it enters the low-pressure cylinder.
ion, and Fig. 77 a sectional plan. The cylinder A is of
ʳ with an inwardly projecting T-shaped annular rib, A^1.



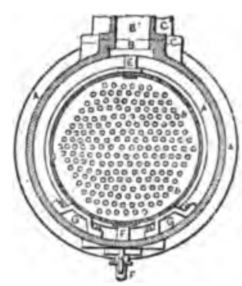


FIG. 77.

ınicating with the exhaust-pipe B^1 of the high-
ɿto the pipe C^1, through which the steam passes
ı reheated. The ends of the cylinders are closed
e screwed two drain-pipes a. A copper or steel
serve as tube-sheets to support the series of
ʰhat is, by expanding their ends. Live steam
ɦh the pipe F. The construction of the cylinders
ɿxhaust steam from the high-pressure cylinder
rtition-rib A^1, passes through the tubes, sur-
r, and then passes through the pipe C^1 to the
mean time the interior of the cylinder D has
ı surrounds all the small pipes, imparting a
ɘ inner cylinder, which is taken up and ab-

ɔbject with inventors to get rid of the com-
ʾred for an expansion and reversing gear.

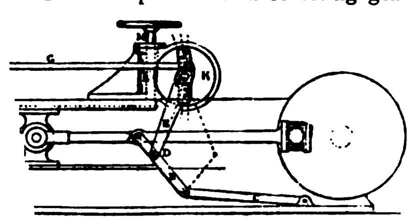


FIG. 78.

od or link B is attached at one end to
ɭe the lower end is joined to the radius-
To a point D in the link B is jointed
ɜnd of the small arm works the valve-
ɜlides in the curved slot J. This slot
ʾ the fulcrum F when the piston is at
ɿal to the length of the valve-rod G.

The disk can be made to rotate through an arc by means of the worm and wheel shown. Thus the slot can be inclined to either side of the vertical. The slot allows the fulcrum of the lever to move up and down with the motion of the point *A* of the connecting-rod. The forward or backward motion of the engine and the rate of expansion are controlled by inclining the slot to one or other side of the vertical, the central position corresponding with mid-gear. If the end *D* of the lever were attached direct to the connecting-rod, the motion of the fulcrum *F* about the center of the slot would not be symmetrical, and the result would be that the cut-off would be unequal in the two strokes. This error is corrected by attaching the end of the lever to the point *D* of the vibrating link; for, while the point *A* on the connecting-rod describes a nearly true ellipse, as shown in Fig. 81, the point *D* describes a bulged figure, and the amount of the bulge is so regulated as to correct the unequal motion of the fulcrum above and below its central position. It is obvious that by shifting the point *D* the amount of the bulge may be altered, and thus the error may be corrected too little or too much, and by taking advantage of this circumstance a later cut-off may be given to either end of the cylinder, if found desirable.

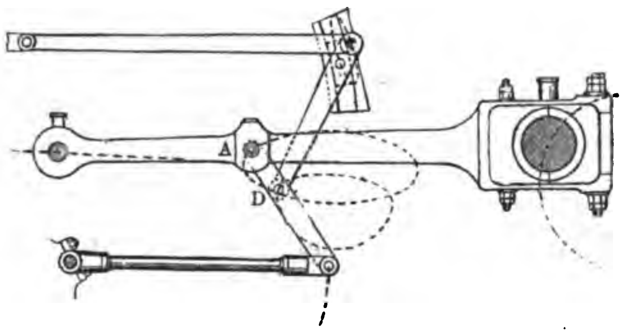


FIG. 79.

Marshall's Valve-Gear, which has recently been fitted to a large number of marine engines, is shown in Fig. 80. In this system only one eccentric is used, the end of the eccentric rod being attached to a rod hung from a pin on the reversing-shaft lever *R*, by which it is constrained to move in an arc of a circle inclined to the center line. To an intermediate point *P* in the eccentric-rod a connecting link is attached, which communicates the necessary motion to the slide-valve rod. By adjusting the position of the reverse lever *R* any desired degree of expansion can be obtained, or the engines reversed, as required. There are few working parts, and distribution of steam both for full power and for expansive working is satisfactory.

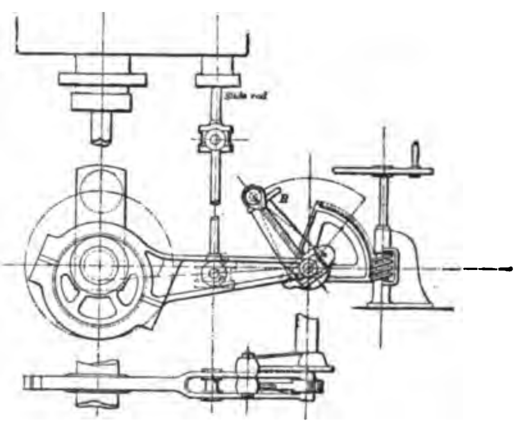


FIG. 80.

II. ENGINE TRIALS AND PERFORMANCES.—*Economy of Small Engines.*—At the Plymouth show of the Royal Agricultural Society of England in 1890 a series of tests as made of small engines, the competition being restricted to those below 5-brake horse-power. Three engines were tested, with the results shown in the following table:

SUMMARY OF RESULTS.	Simpson, Strickland & Co., Dartmouth.	E. R. and F. Turner, Ipswich.	Adams and Co., Northampton.
BOILER.			
Water evaporated per lb. of coal from feed temperature..................lbs.	8·726	7·65	5·978
Equivalent evaporation from and at 212°	10·42	9·065	7·136
Efficiency of boiler	0·689	0·599	0·528
Thermal units transmitted per min. through each sq. ft. of heating surface	59·42	185·4	150·1
Coal burned per sq. ft. of grate per hour..................lbs.	9·635	16·65	12·75
Water evaporated per sq. ft. of heating surface per hour.................. "	3·09	9·71	7·80
ENGINE.			
Piston-speed in ft. per min	298·1	263	240·3
Indicated horse-power	5·641	5·175	6·201
Brake horse-power	5·042	3·997	5·003
STEAM.			
Steam used per indicated horse-power per hour	35·75	64·73	57·75
COAL.			
Per indicated horse-power per hour..................lbs.	4·099	8·461	9·66

…METERS OF CYLINDERS IN INCHES. High …essure.	Low pressure.	Length of stroke in inches.	Relative areas of cylinders.	Lbs. water per I. H.-P. per hour.	Lbs. coal per H.-P. per hour.
30	60	72	1 to 4	......	.....
22	44	60	1 " 4	......	.....
24	48	60	1 " 4	......	.....
16	32	48	1 " 4	......	.....
30	56	48	1 " 3·48	......	.....
26	48	60	1 " 3·41	16·28	.....
24	44	72	1 " 3·36	......	1·69
22	40	60	1 " 3·31	......	.....
20	36	72	1 " 3·24	......	1·63
18	32	48	1 " 3·16	......	.....
32	44	72	1 " 1·89	......	.....
21·62	40·1	59·1	1 " 3·44	{ 14·078 14·586	1·478 1·566
24	40	59·1	1 " 2·78	{ 13·68 14·81	1·436 1·52
25	43	4(⅛	1 " 2·96	15·774	.....
24	52	72	1 " 4·69	18·84	1·87

…f areas of cylinders:

For boiler-pressures above 125 lbs. the triple-expansion engine should be used to get the full benefit of the higher pressures.

See also a paper on the Cylinder Ratios of Triple-Expansion Engines by Prof. Jay M. Whitham, *Trans. A. S. M. E.*, vol. x.

Relative Commercial Economy of Compound and Triple-Expansion Engines.—Prof. J. E. Denton, in a paper read at the meeting of the American Association for Advancement of Science in August,
…uctions to show the relative commercial economy of
…est stationary practice. The table is based on the
…ines built at Augsburg, and those of George H. Bar-
… of detailed estimates of cost obtained from several

…N, OR CORLISS ENGINES …IN COMPOUND RECEIVER-…G TYPE, EXPANDING 16 …ILER-PRESSURE, 120 LBS.		TRIP MOTION, OR CORLISS ENGINES OF THE TRIPLE-EXPANSION FOUR-CYLINDER RECEIVER-CONDENSING TYPE, EXPANDING 22 TIMES. BOILER-PRESSURE, 150 LBS.	
…r hour …meas-…	Lbs. coal per hour per H.-P., assuming 8·5 lbs. actual evaporation.	Lbs. water per hour per H.-P., by measurement.	Lbs. coal per hour per H.-P., assuming 8·5 lbs. actual evaporation.
	1·60 1·65	12·56 12·80	1·48 1·50

…rse-power, including boilers, chimney, heaters, foun-
…... $4 50

	Plant used 300 days, 10 hours per diem.	Plant used 360 days, 24 hours per diem.
…ompound plant................ …iple plant.....................	$9 90 h.-p. 9 " 90 "	$28 50 h.-p. 25 92 " 2 60 "
.... at $.50, or 15 per cent of extra .... 50 per 24 hours................	$0 23 23 15 06	$0 28 28 36 14
	$0 67	$0 96
....	$0 23	$1 64
…el per h.-p. of the compound is	2·3%	5·8%

Trans. Inst. of Mechl. Engrs., Oct., 1886.

…umerous tests of the efficiency of the steam-jackets …vere made by Profs. J. E. Denton and D. S. Jacobus, …e *Trans. A. S. M. E.*, vols. xi and xii.

ortant Parts of Corliss Engines.

Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
14	16	18	20	22	24	26	28	30
6 15/16	7 15/16	8 15/16	9 15/16	10 15/16	11 15/16	12 15/16	13 15/16	14 15/16
14	16	18	20	20	22	22	26	26
4	4 1/2	5	6	6	7	7	8	9
5	6	6	7	8	9	9	9	10
13/16	7/8	15/16	1 1/16	1 1/8	1 3/16	1 1/4	1 1/4	1 5/16
12 1/4	14 1/4	16 1/4	18 1/4	21	23	25	27	29
1 5/16	1 7/16	1 9/16	1 3/4	1 7/8	2	2 1/8	2 5/16	2 1/2
12 1/4	14 1/4	16 1/4	18 1/4	21	23	25	27	29
3 7/16	3 15/16	4 7/16	4 15/16	5 7/16	5 15/16	5 13/16	6 7/16	7 7/16
3 3/4	4 1/2	5	5 1/4	5 1/2	7 1/4	7 1/2	9	9
2 15/16	3 15/16	3 15/16	4 15/16	4 15/16	5 15/16	5 13/16	6 7/16	6 7/16
3 3/4	4 3/8	4 1/2	5 1/8	5 1/4	5 1/2	5 3/4	6 1/4	6[illegible]
4 1/2	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8[illegible]
1 5/16	1 7/16	1 9/16	1 11/16	1 13/16	1 15/16	1 15/16	2 3/16	2 3/16
2 7/16	2 15/16	3 3/16	3 7/16	3 15/16	4 3/16	4 7/16	4 1/2	4[illegible]

ler Compound Engine.—John G. Mair (*Proc. Inst. M.*
the number of expansions that could advantageously
ompound engine, the following were the results of
pumping-engine, raising the boiler-pressure from 60
ere while working throughout at practically the same

ve atmosphere..	60	80	100	120
....	9·2	13·2	14·1	13·7
horse-power per	334	327	325	330

ining somewhere about 10 or 12 expansions, there was
pansion with two cylinders, as the saving in heat ex-
r the increased frictional loss due to the larger cylin-

es of Engine.—The following are common figures for
nes used in electrical work in 1890 (Thurston's *Manual*

....	35 to 40 lbs. water.
nsing....................	25 to 47 " "
g........................	19 to 21 " "
....	16 to 17 " "
....	27 to 29 " "
....	15 to 16 " "
....	13 to 14 " "

steam, the temperature being equalized, the ratios of
engine are about 1 : 2·5 : 7·5.
i-Engine.—Prof. Thurston says that comparison of
conclusions as follows:
philosophy of the steam-engine combine to indicate
r economical application is now so nearly approached
o be both slow and toilsome.
ther improvement upon the best and most efficient of
the difficulties arising in the attempt to reduce it are
s in its reduction.
r be improved by various expedients, including the
n steam, either wholly or partly, no other vapor has
rformance exceeding on the whole, or even equaling,
s.
ntroduction of the silo, a roofed bin or pit for stor-
green corn, clover, and other forage plants, chopped
extraneous moisture excluded, is vastly augmenting
forage for live-stock. The gravity of the mass thus
us nature causes it to ferment and form a firm cake
ly so fast as it is required for feeding by means of a
side of the silo. For convenience, the silo is most
ttle-house, although it may be built separate if pre-

g methods of silo-construction, recommended by E.
indicated in Figs. 1 to 6. Fig. 7 shows the best silo-
D. The drawing shows the inside of the silo-wall.
blocks seals the opening. The two leading essen-

t soon acquire a keen relish for and thrive on it. The flesh-and-milk-pro- remarkable. The available yield of land for stock-feeding purposes is vast-

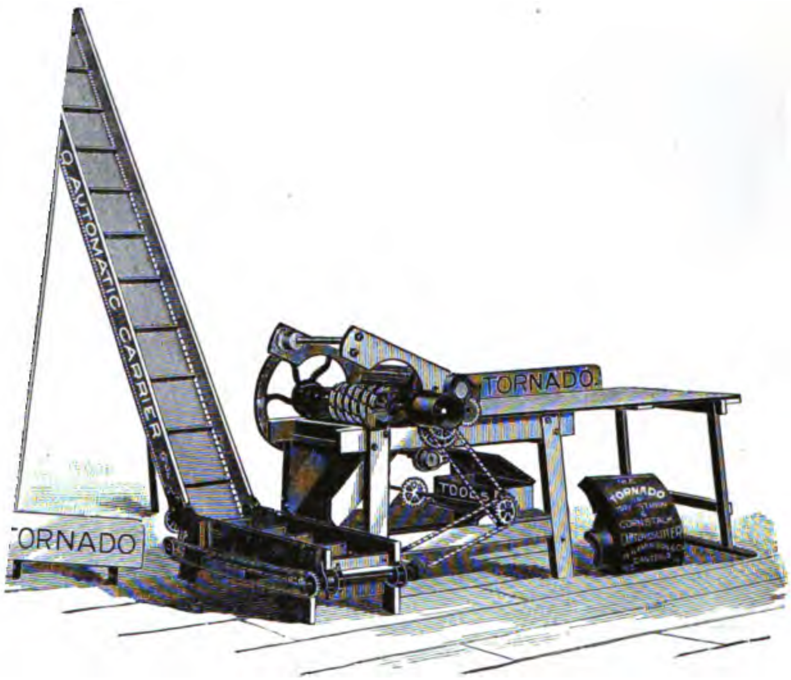


Fig. 8.—Ensilage cutter.

used where it has been introduced. Indian corn, sowed or planted in drills, is the rop giving most profitable results. The corn or other fodder, optionally used, such

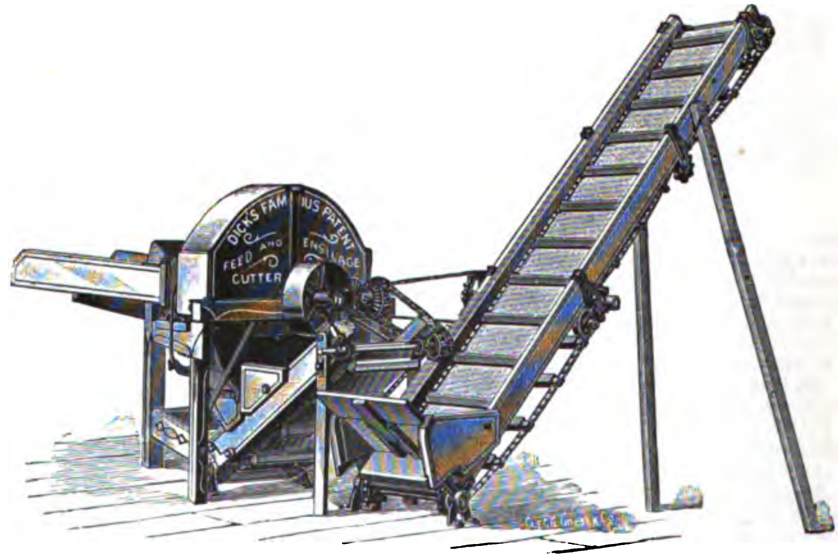


Fig. 9.—Ensilage cutter.

s root-tops, clover or other grass, is to be cut into short lengths, say 2 or 3 in., and some- imes the corn-stalks are also shredded or split as well as cut across. Taken at maturity but before they have begun to become dry, the stalks of the corn-plant, rejected by cattle when dry, are in this succulent stage preferred by them before the leaves, and in the form of ensilage he stalk-joints are the most nutritious part. Special machines are devised for the rapid and economical cutting of the silage. Figs. 8, 9, 10, and 11 represent several standard machines

his purpose, and clearly show the differences in construction. Figs. 12 to 17, inclusive, r various forms of blades adapted to reduce the silage material to the requisite fineness

Fig. 14.—Cutter blade.

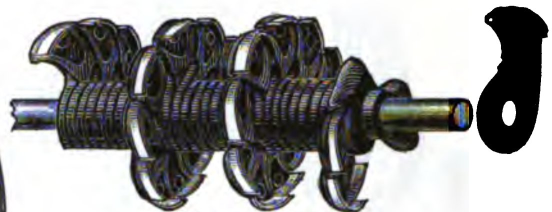


Fig. 15.—Cutter blade.

Fig. 16.—Cutter blade.

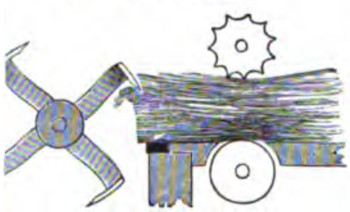


Fig. 17.—Cutter.

condition for compact storage and active fermentation in the silo. Goffart, of France, eemed the efficient originator of the practical application among farmers of this method tilization of products before allowed to dry, and, so far as the richest juices are concerned o waste. In the United States J. B. Brown, of New York, has been prime promoter, and ı great success. Not only the thrift and profitableness of silage-fed cattle must be conred, but the notably increased strength and value of their manure for fertilizing. There ıow an urgent demand from farmers for field machinery capable of harvesting heavy wths of sowed corn and binding the tall plants automatically in sheaves with two bands, convenient transportation from field to the silage chopping-machine at the side of the silo.

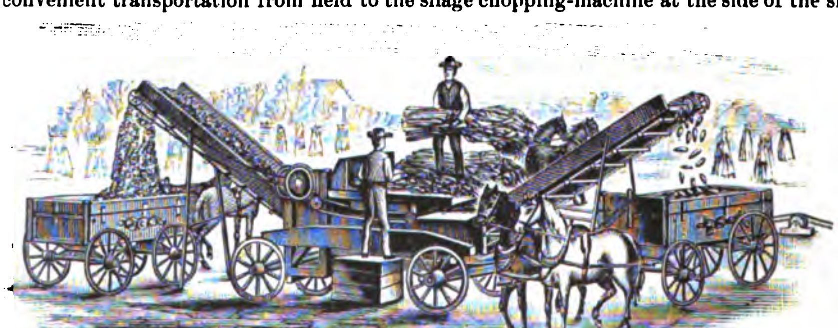
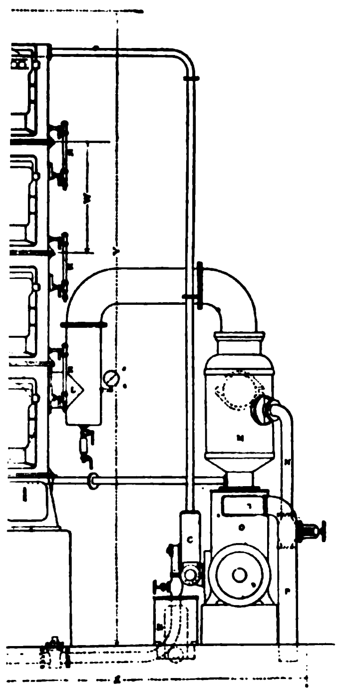


Fig. 18.—Keystone stalk-cutter and husker.

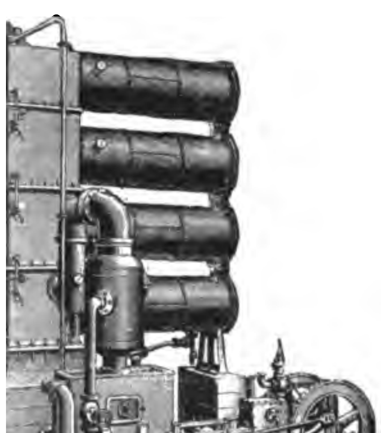
Husking Fodder-Cutter.—The " Keystone " corn-husker and stalk-cutter (Fig. 18) is one of silage-making machines called into being by the introduction of silos, but is to operate rops of corn cultivated for the grain as well as the fodder. The machine delivers at one the ears of corn, stripped of husks and silks, and at the other end the chopped silage. By ting as soon as the kernels of corn have matured, but before the plant has become with- , by standing too long in the field, the value of the fodder for silage may be conserved.

in a recent date the most improved process for the evapo-
devised by Rillieux (see SUGAR-MAKING MACHINERY, vol.



.—Yaryan evaporator–section.

Rillieux was the evaporation by multiple effect, or the the first effect to further concentrate the liquid in the sec- ɔle by producing a vacuum in the evaporating chamber of



'IG. 3.–Yaryan evaporator.

ɔoiling temperature of the liquid. The steam in the sur- ɘby condenses rapidly on the colder surface of the evap- ' imparts its latent heat to the liquid, but produces a rela- The defects of the Rillieux apparatus are. that a consider-

filtration has several serious objections. It is slow, and hence unable to meet heavy drafts on it, as in the case of fire. The filter-beds acting tardily may become foul, which leads to the rapid and enormous development of bacterial life in them, and this may cause the water to become biologically less pure after passing through them than in its original state. There is no quick way of cleaning the filter-beds. In fact, there is no method of simple filtration known that is competent to handle on a commercial basis the water-supply of a large city.

The next step in the evolution of successful mechanical filtration was the addition to water of substances which react chemically with the bicarbonate of lime present in all natural waters, and form a precipitate which assists in removing the suspended matters by filtration. The addition of chemical substances to aid in clarifying water is very old. The most efficient of these substances are those which produce in the water precipitates of a gelatinous nature. The gelatinous precipitate thus formed in the water entangles and agglomerates the minute particles of suspended matter, be they mineral particles or microbes, and forms masses of sufficient size to be easily removed by the filter. Of the substances which produce in natural waters gelatinous precipitates, alum is the most readily obtained and is not surpassed in efficiency by any. The alum and the bicarbonate of lime which is in the water react on each other chemically. The alum is decomposed, and a gelatinous precipitate of aluminic hydroxide, mixed with a basic aluminic salt, is thus formed. The most searching chemical examination fails to show the slightest trace of alum in water that has been treated with the proper amount of it and then filtered.

Alum has been used for many years as a "coagulant" for water with excellent results. The treatment usually consisted in adding a certain amount of alum to the water, mixing it well and allowing the water to stand until the precipitate settled, after which the clear, supernatant water was run off to the filters. While in this way a bright water was obtained, there were still difficulties which prevented commercial success on a large scale. The subsidence plant was unwieldy, and the same difficulties existed with the filters that have been mentioned. Three obstacles remained to prevent the commercial success of filtration of water on the immense scale that large cities require. The first was the difficulties attending the cleaning of the filter-beds; the second was the time required for filtration; and the third, the great size of the filtration plant. It was reserved for us in America to solve the problem in a most ingenious way, and to devise a process that has made the cleaning of the filter-beds simple and effective; that has diminished the time of filtration to a practical minimum, and has greatly reduced the size of the apparatus.

The principles of the process now generally in vogue here are briefly as follows: On its way to the filter the water receives the addition of a minute amount of a saturated solution of the coagulant, usually alum. The amount of coagulant added varies with different waters, and even with the same water at different times of the year. Usually it amounts to about one fifth to one third of a grain to the gallon. The water having received this small dose of coagulant, so small that it seems incredible that it should produce such remarkable results, passes, without stopping to settle, directly to the filters. The most generally adopted form consists of large closed cylinders of boiler-iron filled with sand, or a mixture of sand and coke. The coagulated water passes down through these filter-beds and comes out clear and sparkling, as delicious and as tempting as a mountain spring.

Nature, however, is not content with coagulating and filtering water, but at the first opportunity sends it tumbling over some precipice, to fall against rocks and be dashed into spray until it reaches the bottom a mass of foam. In doing this Nature effects in a simple way something that has greatly perplexed engineers to imitate—i. e., to aërate water in a practical way. This aëration fills the water with myriads of minute bubbles of air. The surface of contact between the water and air is immense, owing to the enormous number of air-bubbles. In this way the water is subjected to the powerful influence of the oxygen of the air, which destroys the dissolved organic impurities, and not only kills many of the lower forms of life, but makes the life of many others hazardous by removing the organic matter on which they feed. The artificial aëration of water has been effected in the following way: A large vertical pipe many feet in length is turned back on itself so as to form a great U. Into one end of this the water is injected and falls tangling up the air with it and emerging from the other end as foam. Water so aërated takes hours to lose its air, so minute are the bubbles. The effect of this aëration is to oxidize the dissolved organic matter and greatly purify the water. To return now to the filter. After a certain duration of filtration the filter-beds become so clogged with the separated coagulum and filth that filtration becomes difficult, and if allowed to go on would soon yield a foul water from the growth in them of micro-organisms, and instead of purifying would render the water organically less pure. Long before any danger of such a catastrophe the cleaning of the filter-beds takes place. To accomplish this the current of water is reversed, and, instead of flowing down through the filter-bed, is sent with great force up through it from the bottom. The entire bed of sand is thus lifted and floats, as it were, on the ascending stream of water, yielding up all its impurities, which escape with the water through a waste-pipe. The washing of the filter is continued until the wash-water runs clear, when, by turning a few valves, the flow is reversed again and filtration is resumed. So simple are the operations of filtration and washing the beds, that one man can handle a plant filtering several millions of gallons per day.

The effect of this method of filtration on the purity of water is most remarkable. Thus the analyses of the water of the city of Atlanta, Ga., before and after filtration furnish incontestable proof of the success of the process there employed:

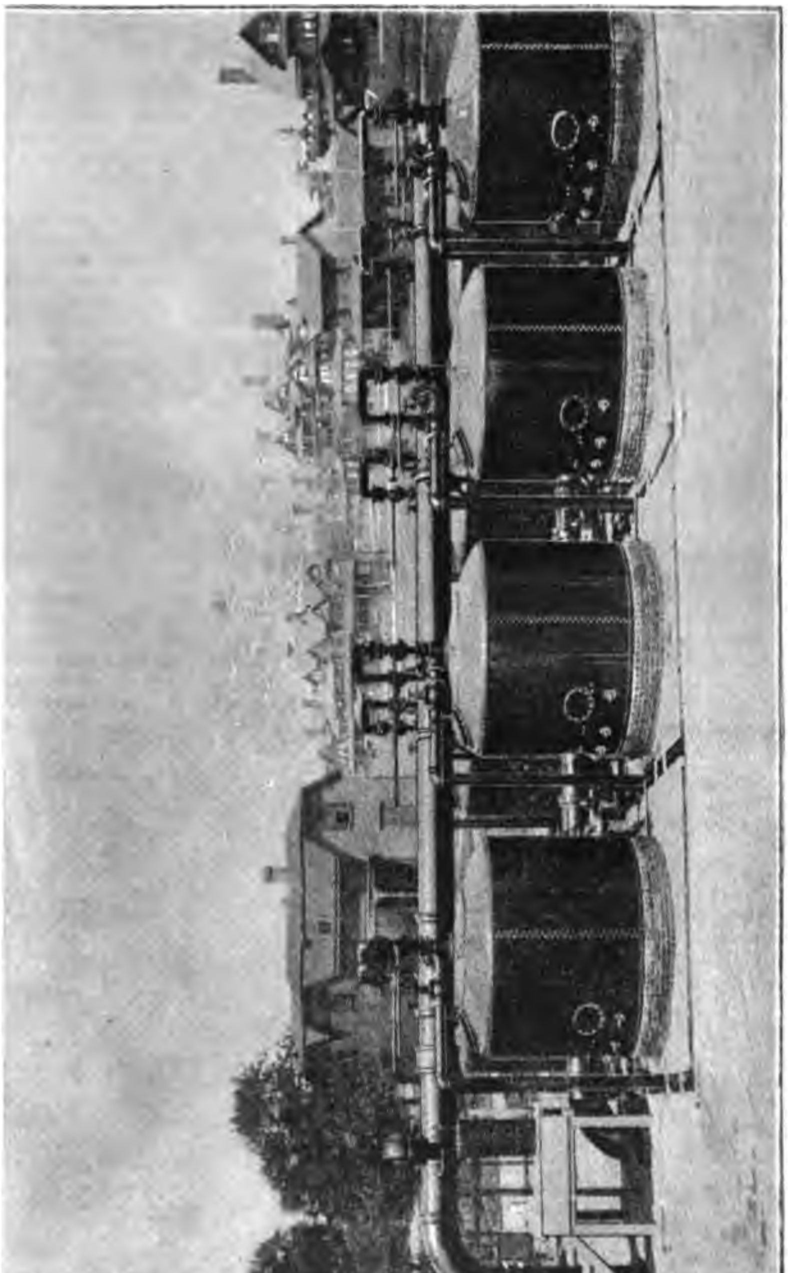


FIG. 2.—Hyatt filtering plant, Long Branch, N. J.

ıghly cleaned with the minimum consumption of water. Experiments also ι that insufficient time was usually allowed for the reaction of the alum or sed in the water; hence, in the Warren system, the coagulant, in the form of nite strength, is pumped into the water as it passes to a settling-basin or ›ned in size as to allow each particle of water to remain in contact with the coagulant the length of time found necessary for the chemical reaction. In this way it is claimed that a greater economy of the coagulant is obtained, and the possibility of its passing into the filtrate is removed—a point of much value where the water is used for domestic purposes. The filter, by combining coagulation, sedimentation, and filtration, by the use of an open filter-bed so arranged as to be quickly and mechanically freed from the intercepted matter, and by the use of a light pressure never exceeding $\frac{1}{10}$ lb. per sq. in., is intended to unite all desirable features with a comparatively inexpensive form of construction.

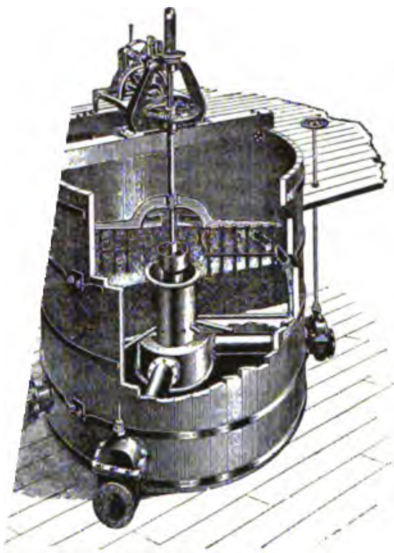


FIG. 3.—Warren filter.

From Fig. 3, which clearly exhibits the internal mechanism, the operation of this filter will be understood.

During filtration, the unfiltered water, entering through the valve, passes up into the filter-tank, thence downward through the filter-bed, supported by the perforated plate, and through the filtered water-main, by which it is carried to the mill. When it becomes necessary to cleanse the filter-bed the valves are adjusted to allow the water in the tank to pass into the sewer. When the water in the tank has been drawn off, the agitator is set in motion, ven down into the bed by means of the screw shown, while at the same time a slight t of filtered water is allowed to flow back up through the bed, in order to rinse away ·t which has been loosened by the scouring action of the revolving agitator. When the ! water up through ed becomes clear ıgitator is raised, waste-gate closed, by the opening of valves filtration is med.

The National Filter. his filter, manufaced by the National ıter-Purifying Co. of ;w York, is represent- . in section in Fig. 4. he filter proper is about wo thirds filled with in- estructible fine quartz ea sand. In the top of :he filter-case is shown a device for supplying a minute quantity of chemical solution to the water when it is very roily or turbid or impregnated with sewage, the effect of the chemical being to precipitate the impurities in solution and suspension, while the chemical itself is retained with the impurities it precipitates upon the top of the filtering material, so that no trace of it (even by analysis) appears in the filtered water. In the bottom of the filter are shown the brass tubular strainers for preventing the sand passing out with the filtered water. These strainers

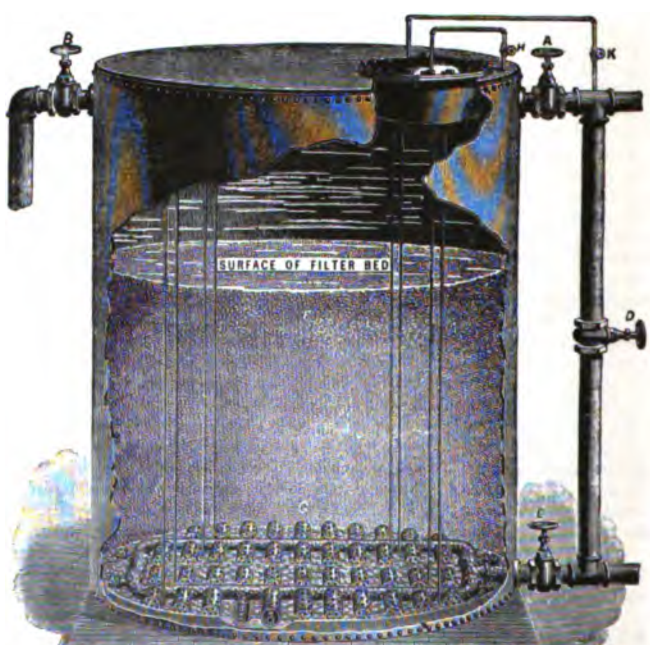


FIG. 4.—National filter.

so as not to retain ice and to afford a sure footing. The balconies are also of iron, and, being securely anchored to the wall, form a vantage-ground for the firemen, from which they can cope with the flames on a level with them and from the outside of the building. An example of the second class of fire-escape is given in Fig. 2. Here is shown a series of three connected ladders, one sliding upon the others. The three may be brought into prolongation by means of a simple chain and windlass. The ladder in position to raise is represented at 1. At 2 it is elevated and ready for extension. At 3 it is shown fully extended and ready for service. The length of the three ladders jointly is 70 ft. The upper or top ladder is held in position not only by the elevating chain, but by two supporting hooks, which automatically clasp the rounds, and also by self-acting brakes, so that in event of breakage of the chain the ladder can not slide down. An example of the third class of fire-escape is given in Fig. 3. The lowering rope is fastened securely to the wall, usually near the window-casing. It passes around a fixed bar in the lowering device and then between the parts of a brake or clamp, which is provided with a hand-lever. A belt or sling, as shown in the figure, is connected to the lowering device, and supports the person, who, by manipulating the brake, allows himself to slide down the lowering rope as rapidly or slowly as may be desired.

Fig. 3.—Fire-escape.

FLANGING-MACHINES. A variety of new forms are presented.

The Davis Flanging-Machine.—Fig. 1 represents a boiler-head flanging machine, built by I. B. Davis & Son, of Hartford, Conn., designed for flanging heads of any size from 38 to 96

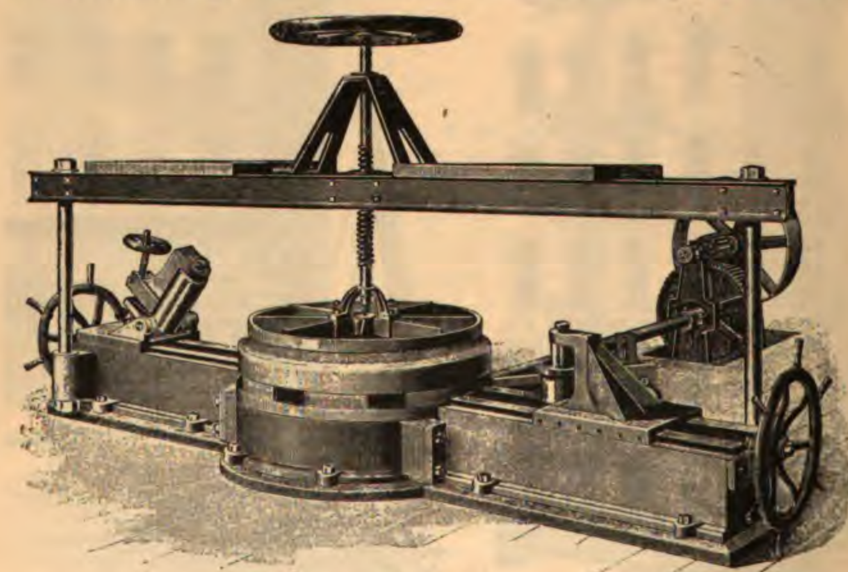


Fig. 1.—Davis flanging-machine.

in. diameter, and of any thickness required within those limits of size. In the center of the machine is a revolving plate, driven by a powerful train of gears, and which is adapted to receive and drive the former over which the head is formed. At the back of the machine are two arms having T-slots, by which are attached gauge-blocks, having swinging pieces, by which the head is centered on the former. The follower plate is then brought down on to the

head by means of the screw and hand-wheel at the top. This follower is so made as to bear hardest at the outside, and comes down with an outward pressing motion, which keeps the

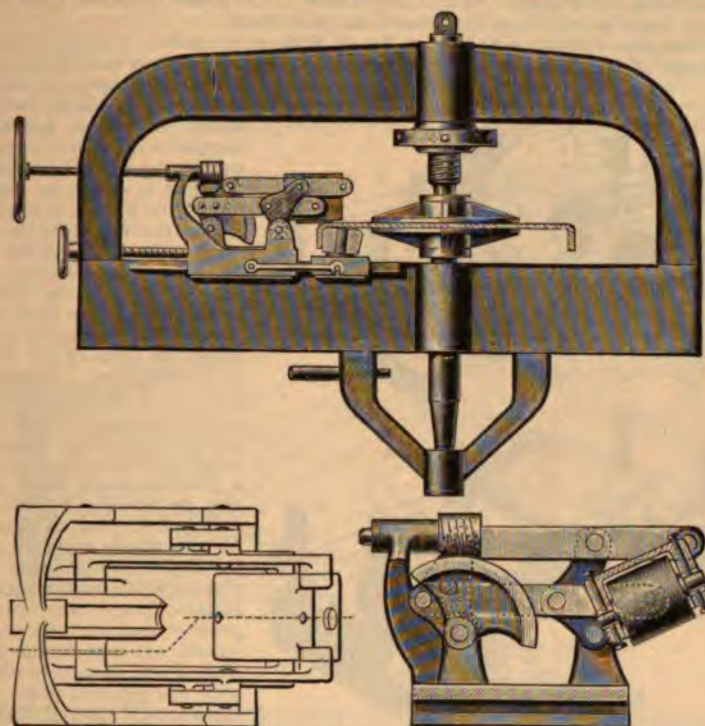
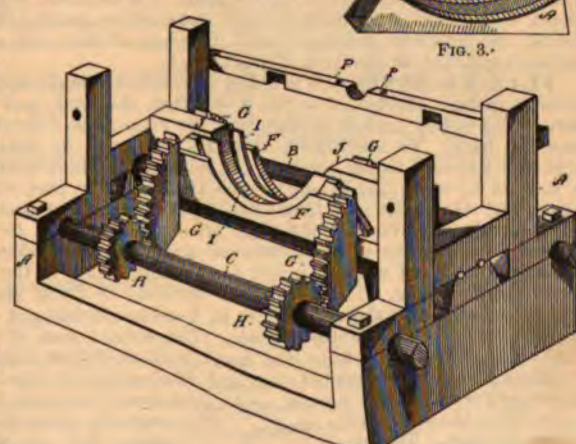


FIG. 2.—Clark's flanging-machine.

head straight and flat on the former while being turned. The machine is then set in motion, and the straight or "break-down" roll brought against the edge by means of the large screw in the bed. This roll is so mounted as to enable it to be presented at any desired angle, and can then be gradually brought to a vertical position by means of the hand-screw on the carriage, being kept up to the head at the same time by means of the large hand-wheel and screw. The finishing-roll, which is made of the shape it is desired the head to be, is at the opposite side of the machine, and is brought up to the head in the same manner, though it is fixed in a vertical position. As the first roll is bringing the edge of the head down to the former, the finishing-roll is brought up and completes the head. Hooks are placed in the follower, which take hold of the lower edge of the head, so that it is drawn off by means of the hand-wheel and screw on the top of the machine.

FIG. 3.



FIGS. 3, 4.—Kent's flanging-machine.

Clark's Boiler-Head Flanging-Machine, made by Jacob Clark, of Germantown, Pa., is shown in Fig. 2. The plate to be flanged is clamped between two disks and rotated with its edge projecting over a short vertical roller. A swiveling-roller turns the flange down as the plate passes quite rapidly under it. This upper or swiveling roller is carried in a housing supported by two parallel levers, which are actuated by worm-gearing and hand-wheel, as shown. By the motion obtained by the combined action of the parallel levers the upper roll swivels from a horizontal to a vertical position, directly round the center of the fillet in the

head being flanged, giving a smooth, easy motion for the flow of the metal into its new form. The saddles carrying the two rollers are adjustable along the bed, thus making heads of varying diameters without formers. No hole is necessary in the plate. Heads of exactly uniform diameters are made as rapidly as the furnace can heat them.

Kent's Flanging-Machine.—Figs. 3, 4, 5, and 6 show a machine (patented by William Kent, February 15, 1887) for bending and flanging connecting pieces or saddles for water-tube boilers or shapes of similar construction in which two parallel plates of metal require to be flanged in opposite directions. The connecting piece to be made by the machine is shown in Fig. 3. Referring to Figs. 4, 5, 6, the following is a description of the machine:

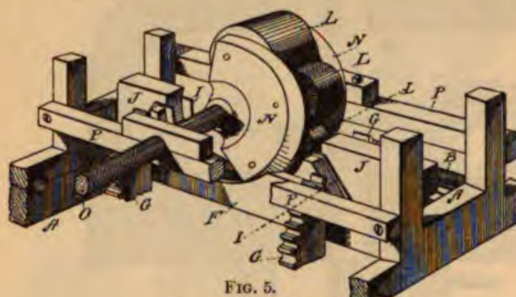


FIG. 5.

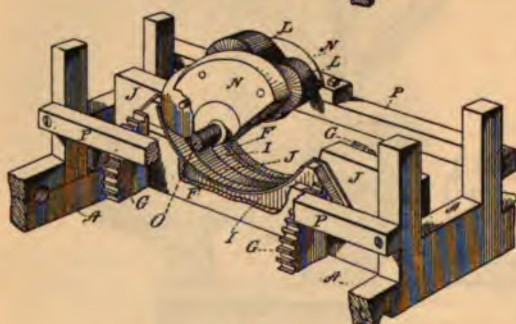


FIG. 6.

FIGS. 5, 6.—Kent's flanging-machine.

A is the frame of the machine. B C are shafts, having mounted thereon, outside the frame, gear-wheels, adapted to mesh with each other. F F are leaves pivoted between the sides of the frame so as to be capable of a swinging movement, while at the same time, when in their normal position they are in the same horizontal plane with the ledge between them, thus forming a platform upon which the blank may be placed. To the inside of each leaf are secured segment-gears G, with which mesh the cogs H on the shafts B C. Upon the blank I is superimposed an anvil, J, of suitable shape, according to the product desired. By turning the wheels external to the frame the cogs H will operate in conjunction with the segment-gears G to fold the leaves F upward. This operation is continued until the leaves have caused the blank to be bent at the desired angle (in this instance a right angle), when the blank is ready for the operation of the flanging mechanism, as seen at Fig. 4. The mechanism for flanging consists of a series of rolls, L, preferably three in number, the outside edges of all but one being beveled. These rolls are journaled within a box, N, secured on a shaft, O. This shaft O is mounted within suitable bearings on cross-pieces, P, secured to the frame, and is operated by gearing (not shown). As the shaft is revolved the rolls will gradually bend the edges of the blank and form thereon an outwardly projecting flange, as shown in Figs. 5 and 6.

FLAX-MACHINES. When flax is pulled, the stalk may be said to be made up of three distinct parts. There is first the wood, then the bark, and lastly the glossy varnish of the bark. The woody matter in flax is of no value; the difficulty is how to get rid of it and to save the bark. To accomplish this the flax must be retted, and it is either spread over a field and exposed to the weather for some time, which is called "dew-retting," or the straw is steeped in water. In a short time the vegetable part rots, the gum on the outside dissolves, and the stalks are taken out of the water and dried. But the wood is like a fixed finger inside a glove, and, although weakened, has still to be removed. Scutching is the process by which the wood is removed and the outside skin saved. The difficulty is to get the woody part out without injury to the skin, which is the valuable part of the plant and forms the flax-fiber. There are four methods of doing this. The first is by striking the flax repeated blows, then taking it in handfuls, holding it over a wooden rest, and striking it sharp blows with a wooden blade. The second plan is to run the retted straw through fluted iron rollers, and when the heart is thus broken into short bits to take the straw in handfuls and hold it against two end blades rapidly revolving upon a shaft. The process known as the "Cardon" process, and which promised great things a short time ago, consists in pricking the straw with needles. This cuts the straw into lengths so small as to make it practically dust. The straw comes easily away. But it is obvious that the skin is damaged at the same time, because the heart of the stalk must be got at through this outer skin.

The Spiegelberg Flax-Scutching Machine (Figs. 1 and 2).—A new scutching-machine has been devised by Mr. A. Spiegelberg, which is claimed to show material improvement over older devices. The flax-straw is fed into the machine, one end always overlapping the preceding one. Heavy fluted rollers flatten the tubular stalks, which action does not spoil the fiber, but only takes the resistance out of the straw. Then the flax proceeds to the small rollers, lightly fluted, just sufficient to obtain a thorough grip of the flax, and by means of suitable mechanism these rollers receive a lateral or shaking motion, which bends the stalks and al-

lows the wood to fall out, and also prevents the outer skin from becoming crushed or cut, as is the case with the needle-points, or the series of fluted rollers—run at a high speed—of other machines. The fiber then passes to the second part of the machine, as illustrated herewith, which somewhat resembles an intersecting heckling-machine. The "strike" of flax is secured between a pair of India-rubber gripping-rollers $C\ C^1$, which bring it into contact with a pair of rapidly revolving beaters $D\ D^1$. After this operation has gone on for a given time the beaters are caused to revolve in the opposite direction, the gripping-rollers $C\ C^1$ and $E\ E^1$ are respectively automatically opened and closed in the interval by means of cam-bars $F\ F^1$, and the cams G and levers H. In this manner both ends of the strike are sufficiently operated

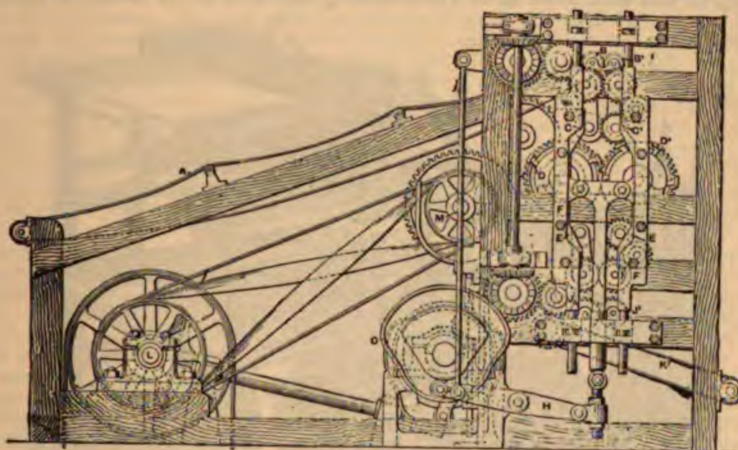


FIG. 1.

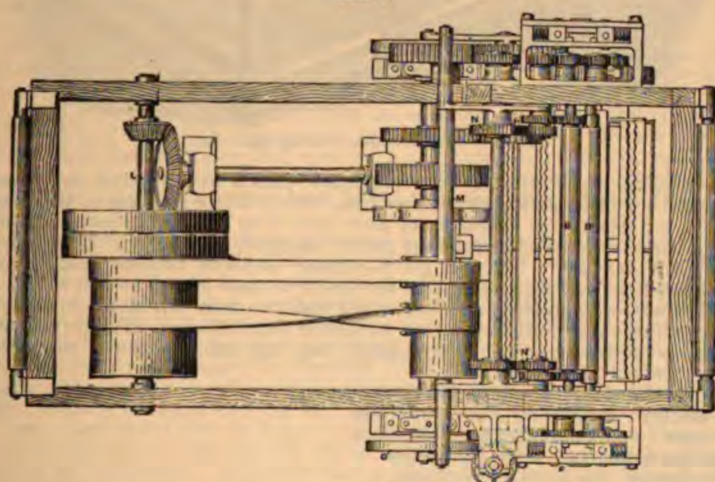


FIG. 2.

FIGS. 1, 2.—Spiegelberg flax-scutching machine

upon before they are allowed to proceed downward to the delivery roller $J\ J^1$, and thence to the delivery-apron K. L is the first-motion shaft, carrying fast and loose pulleys, connected with similar pulleys on the shaft M, from which the beaters are driven. The taking-in rollers $B\ B^1$ derive motion from suitable gearing N, which is so constructed as to allow itself to become automatically disengaged upon the reversal of the machine. The principal part of the process, however, is that involved in the breaking-machine, which can not be substituted by hand or other process, while the cleaning might be done in the ordinary way; in fact, when the flax is well retted the breaking is done so completely that a little handling cleans the fiber entirely from all show. The two machines may be worked separately. It is obvious that, the fiber being uninjured, there is a much larger output, and the heckle gives far more yield in line. About the importance of scutching there can be no question. Vast countries produce grasses and fibers which are of the highest value. The difficulty always has been to separate the fiber from the gummy exterior and from the inside pith or wood.

The Wallace Flax-cleaning Machine.—A flax-cleaning machine of novel design, devised by Mr. John O. Wallace, of Belfast, Ireland, is illustrated in Fig. 3. It is shown with the buf-

fer alongside, which is used for dislodging the woody matter. The machine is about 6 ft. 6 in. high by 4 ft. wide, and 5 ft. long over all; its working capacity being put at 1 cwt. of retted flax per hour. It consists of an upper feed-table, on which the flax straw is fed to three pairs of fluted rollers, which deliver the flax downward between five pairs of pinning-tools, alternating with six pairs of guide-rollers. The pinning-tools somewhat resemble hand-hackles, and are attached to two vertical frames, to which a horizontal to-and-fro motion is imparted, and the pins interlace as the two sides approach. The fibrous material is drawn downward by the rollers, which have an intermittent motion, and at each momentary pause the pricking-pins enter the material and are rapidly withdrawn from it. By degrees this fibrous descending curtain is delivered on to a sloping receiving-table at the bottom of the machine,

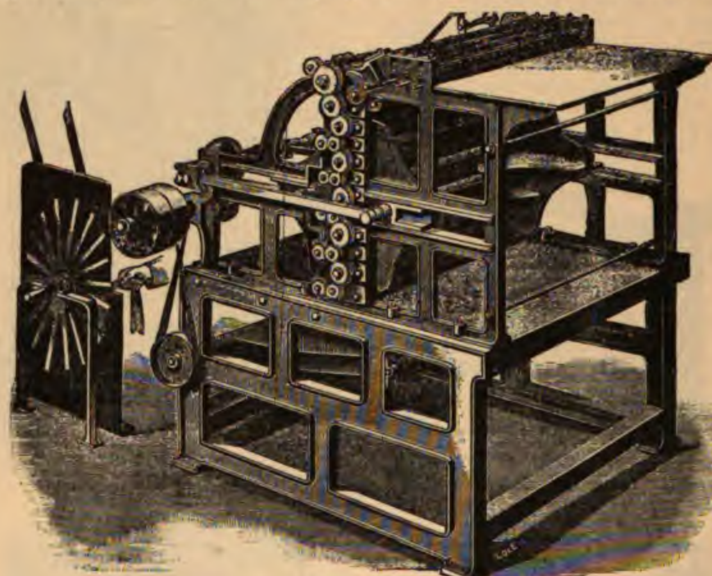


FIG. 3.—Wallace flax-cleaning machine.

over which table the woody substance has previously passed to a receiver in a crushed and semi-pulverized condition and perfectly free from fiber. Three attendants are required for one machine; but when large quantities of fiber have to be cleaned the same attendants are sufficient for three or four of the machines placed alongside each other. The attendants for one machine for flax are a boy or a girl to prepare straw in bundles, another to feed the straw to the machine, and a man to attend the buffer to clear off the broken woody portions. The two attendants who prepare the bundles and feed the straw can attend to two other machines, but each machine must have a man to buff or clean the flax. The driving power for each machine is two horse-power. It is claimed that this machine can be successfully used for cleaning ramie or rheea fiber.

Flight, Mechanical: see Aërial Navigation.
Flour-Bolter: see Milling-Machines, Grain.
Fly-Frame: see Cotton-Spinning Machines.
Flying-Machine: see Aërial Navigation.
Fodder-Cutter: see Ensilage-Machines.
Folder: see Book-Binding Machine and Presses, Printing.
Forced Draft: see Engines, Steam, Marine.
Forging: see Presses, Forging.
Fork, Hay: see Hay Carriers and Pickers.
Forming-Lathe: see Lathe, Metal-Working.
Friction of Engines: see Engines, Steam, Stationary Reciprocating.
Friezer: see Molding-Machines, Wood.
Fuel Consumption: see Furnaces, Blast, and Locomotives. **Fuel-Feeding Devices**: see Stokers, Mechanical. **Fuel, Gas**: see Gas-Producers. **Fuel, Petroleum**: see Engines, Steam, Stationary Reciprocating.
Furnace, Bullion Melting: see Mills, Silver. **Furnace, Glass-Making**: see Glass-Making. **Furnace, Open-Hearth**: see Steel, Manufacture of. **Furnace, Petroleum**: see Engines, Steam, Stationary Reciprocating.

FURNACES, BLAST. *Recent Development of American Blast-Furnaces.*—A paper read by Mr. James Gayley, superintendent of the Edgar Thomson Furnaces, Braddock, Pa., at the New York meeting of the Iron and Steel Institute, in September, 1890, gives a very full history of the development in blast-furnace practice since 1880. We extract from this paper as follows:

The development of blast-furnace practice in America in the direction of large yields is mainly the history of our working since the year 1880, as the advancement that has been made in the last decade is greater than that in the third of a century previous. A new era in the manufacture of pig-iron began in 1880 with the putting in blast of the Edgar Thomson furnaces. These furnaces at once leaped to the front as pig-iron producers, and have maintained that position—with but one brief interruption—ever since. As an example of the best work that was done in the ten years previous to that time, the Lucy furnace No. 2, of Carnegie, Phipps & Co., of Pittsburgh, may be noted. This furnace was built in 1877, of the following dimensions: Total height, 75 ft.; diameter of bosh, 20 ft.; diameter of hearth, 9 ft.; cubical capacity, 15,400 ft. The bell generally in use was 11 ft. in diameter. In the construction of this furnace, the noticeable features are a narrower hearth and a wider top than are now put in furnaces of the same cubical capacity; but at that time it was considered an excellent shape, and certainly did produce some excellent results. As early as 1878 this furnace had made a monthly output of 3,286 tons, on a coke consumption of 2,793 lbs. per ton of iron; and in one week shortly afterward made 821 tons. For the first 12 full months the output was 33,552 tons, on a coke consumption of 2,850 lbs. The amount of air blown was 16,000 cub. ft. per min., which entered the furnace through six 8-inch tuyeres; the temperature of the blast was 915°, and the pressure at tuyeres 5 lbs. The ore mixture yielded in the furnace 60 per cent iron. The work that was done at this furnace was unquestionably the best, all things considered, that had been accomplished prior to the starting of the Edgar Thomson furnaces.

Furnace "A" of the Edgar Thomson works was erected in 1879. The dimensions of this furnace are as follows: Height, 65 ft.; diameter of bosh, 13 ft.; diameter of hearth, 8 ft. 6 in.; cubical capacity, 6,396 ft. Six tuyeres, 4 in. in diameter, were used; these, projecting 7 in. inside the crucible, made the efficient diameter of hearth 7 ft. 4 in. The tuyeres were placed 5 ft. 6 in. above the hearth-line. The interior lines made very small angles with each other—so small, in fact, that the arc of a circle drawn from the top to the tuyeres will not deviate more than 2 in. from the lines as given. Particular attention was given to rounding the angles. The bosh was located about midway in the furnace, making the bosh-wall very steep. The batter of this wall was 1⅜ in. to the foot, which is equivalent to an angle of 84°. The furnace was lined throughout with small bricks. The stove equipment consisted of three Siemens-Cowper-Cochrane stoves, 15 ft. in diameter by 50 ft. in height. This furnace was "blown in" in January, 1880. The ore mixture yielded in the furnace 54·5 per cent iron. The output of the first full week was 442 tons, and reached 537 tons for the fourth week. The best week's output was 671 tons. The blast was heated to an average temperature of 1,050°, the utmost that the stoves would furnish; the pressure at the tuyeres was 6¼ lbs.

The volume of air forced into this furnace was 15,000 cub. ft. per min., or as much as was used elsewhere for furnaces of more than twice the capacity. The results obtained were surprising. Considering the cubic capacity of the furnace, the rate of driving was certainly excessive, and that the results on fuel were so low, as compared with the subsequent consumption on larger furnaces where the same practice was employed, is mainly due to the narrow furnace-stack. These fuel results were much lower than any obtained from the larger furnaces in the next five years.

The second furnace erected at these works had general dimensions as follows: Height, 80 ft.; diameter of bosh, 20 ft.; diameter of hearth, 11 ft.; cubical capacity, 17,868 cub. ft. The stock was distributed at the top by a double bell, in which the central cone remained stationary; while the outer conical ring, being lowered, cast the stock toward the wall and center of the furnace. One feature of this construction, differing from that of other furnaces then using coke for fuel, was the large hearth, providing more space for combustion. The in-walls of the hearth were straight, and the diameter 11 ft. There was an increased number of tuyeres, eight being used, and an increased elevation of tuyeres above the hearth-level, all of which were necessary for rapid driving and large yields. No American furnace up to that time had been constructed with so large a hearth as this one at the Edgar Thomson works. In another respect this furnace was well prepared by its designers for a high productive capacity, viz., in its equipment. Fire-brick stoves of the most approved type were erected. Substantially built blowing engines were provided, and they were rendered efficient by an ample supply of boilers—a point in which other furnaces were then sadly lacking. At the same time, all the flues and mains were constructed sufficiently large, and in the most substantial way. In fact, no furnace previously erected had been planned on such a liberal basis; consequently, large yields were to be expected. The furnace was put in blast in April, 1880. In the following month an output of 3,718 tons was made, and the next month showed 4,318 tons; thus fully justifying the claims of its designers by eclipsing all previous records. The weight of limestone was 25 per cent of the weight of the ore. An analysis of the cinder showed: silica, 32·31 per cent; alumina, 13·20 per cent.

The limestone contained a very small quantity of magnesia. The blast entered the furnace through eight bronze tuyeres of 5¼ in. diameter, and was heated to a temperature of 1,100°. The silicon in the iron averaged about 2 per cent. The rapid wear of the furnace-walls, through the use of such a large volume of air, gradually increased the consumption of coke to over 3,000 lbs. per ton of iron. At the end of the first 12 full months the output was 48,179 tons, on an average coke consumption of 2,859 lbs. per ton of iron. The second year showed an average consumption of 3,200 lbs. of coke, with a decrease in yield. The furnace was blown out after a blast of two years and five months, having made a total product of 112,060 tons, on an average coke consumption of 3,149 lbs. per ton of iron. The results ob-

tained in this blast determined several important changes in construction. The crinoline structure was torn down and replaced by an iron jacket; the bosh-walls were protected so as to preserve as far as possible the original lines, and the hearth was surrounded with water-cooled plates. The double bell was also found to possess no special advantage, and was abandoned.

The practice of rapid driving, begun on furnace "A," and further developed on this one, had an important effect on the general practice of this country. The great outputs obtained from this furnace by the use of a large volume of air, was a matter of common knowledge; the practice of fast driving soon became the accepted one, and with our national ardor it was prosecuted enthusiastically. In every direction engines that had been running along for years at a methodical gait were oiled up and started off at a livelier pace; new boilers were added; the old iron hot-blast stoves, not supplying sufficient heat, were torn down and replaced by the more efficient fire-brick stoves. At many works rapid driving degenerated into excessive driving. True, the outputs increased; so also did the consumption of fuel, and that at a surprising rate, until it was thought well-nigh impossible to produce a ton of iron with 2,600 lbs. of coke. Although the practice of rapid driving has been much decried, yet in many ways it has resulted beneficially. It has brought in an equipment of hot-blast stoves, boilers, engines, etc., sufficient to accomplish a large amount of work without a constant strain on every part—a condition very rare prior to 1880; and it has also developed a construction of the furnace-stack by which larger outputs from a single lining can be obtained with less irregularity in the working.

Furnace "D" of the Edgar Thomson works, built in 1882, was of different construction from either of the preceding. It was constructed with special regard to the better protection of the brick-work of hearth and bosh. The general dimensions were as follows: Height, 80 ft.; diameter of bosh, 23 ft.; diameter of hearth, 11 ft. 6 in.; stock-line, 17 ft.; bell, 11 ft.: cubical capacity, 21,478 ft. The bosh is placed at about the center of the stack, making very steep walls. The hearth is also made wider by 6 in. than in furnaces previously described. The hearth-walls are surrounded by cast-iron plates with a coil inside for the circulation of water. Around the bottom of these plates is a gutter, through which waste water from the cooling plates flowed, affording better protection to the bottom of the hearth. Above this row of plates, at the tuyere breasts, is another circle of cooling plates, partially inserted in the brick-work. The walls of the bosh are incased in a jacket of wrought iron, ½ in. in thickness. This jacket is bolted on to the mantle. The bosh-walls inside the jacket were made but 22½ in. thick, so that the cooling effect of the air-currents on the jacket would prevent any very rapid wear of the brick-work. This furnace was put in blast in 1882. In the first 12 full months the output was 65,947 tons, on an average of 2,570 lbs. of coke per ton of iron, thus exceeding, by over 11,000 tons, the best output that had previously been obtained in the same time from any furnace at these works, and with a much smaller consumption of fuel. The record for the best month during this period was 6,131 tons, on a coke consumption of 2,387 lbs. per ton of iron. The amount of air blown was 27,000 cub. ft. per min., which was heated to an average temperature of 1,000°. The pressure of blast at the tuyeres varied between 9 and 10 lbs. After a blast of 17 months' duration this furnace was blown out, having made a total output of 90,317 tons, on an average coke consumption of 2,613 lbs. per ton of iron.

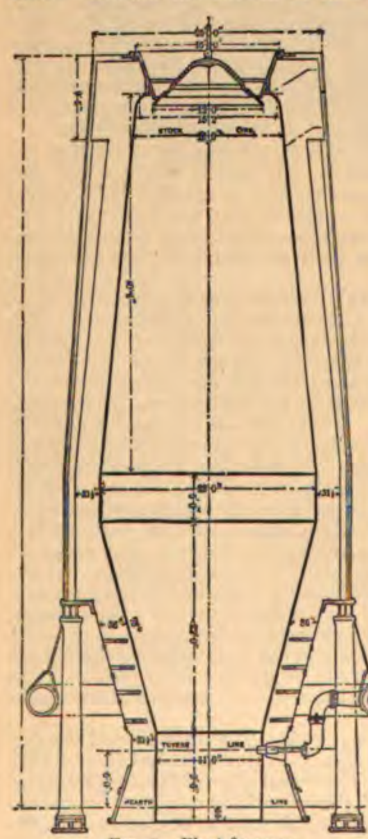


FIG. 1.—Blast-furnace.

Furnace "C" was reconstructed in 1885, with the following dimensions: Height, 80 ft.; diameter of bosh, 20 ft.; diameter of hearth, 10 ft.; diameter of stock-line, 16 ft. 3 in. The bosh-walls had an angle of 79°, and all the lines were joined by curves. The cubic capacity was 16,680 ft. In February, 1885, the furnace was "blown in." The volume of blast was rapidly increased until, in the following month, it reached 31,000 cub. ft. per min. The blast entered the furnace through eight tuyeres, 7 in. in diameter, and was heated to an average temperature of 1,200°. The pressure at the tuyeres was 8½ lbs. The average monthly output from March to August, inclusive, was 5,122 tons, on a coke consumption of 2,874 lbs. per ton of iron. Attempts were made later to increase the economy by reducing the volume of blast to 28,000 cub. ft. As a result the output increased to an average of 6,050 tons per month, on a coke consumption of 2,400 lbs. per ton of iron.

This furnace was again reconstructed in 1887, the hearth being widened to 11 ft. diameter, the bosh to 21 ft., and the stock-line reduced to 15 ft. The cubic capacity was increased to 17,230 ft. The furnace was "blown in" in March, 1887. On account of the brick-work in the bosh being very much worn, the furnace was blown out after a run of 2 years 7 months and 17 days—exclusive of the time the furnace was banked. The output for the blast was 203,050 tons, on an average coke consumption of 2,342 lbs. per ton of iron. The output for the first 12 full months was 72,554 tons, on a coke consumption of 2,230 lbs. For the second 12 months, during which no stoppage occurred, the output was 83,219 tons. The best output made in any one month was 7,680 tons. The furnace shown in Fig. 1 was built in 1886. The total height is 80 ft.; the diameter of hearth, 11 ft.; the diameter of bosh, 23 ft. The bell is 12 ft. in diameter, and the stock-line 16 ft. The cubic capacity is 19,800 ft. There are 7 tuyeres, each 6 in. in diameter. The furnace was started in October, 1886, and was in blast—exclusive of two stoppages—2 years 7 months and 10 days, and made in that time 224,795 tons of iron, on an average coke consumption of 2,317 lbs. The output for the first 12 full months was 88,940 tons on 2,150 lbs. of coke. The efficiency of the cooling plates on the bosh-walls was very marked in this case. The exterior brick-work was in as good condition at the end of the blast as at the beginning. The interior of the boshes had widened out 18 in., but with such uniformity that the greatest variation did not exceed 2 in. From the bosh-line to the top of the furnace the wear was much greater. The furnace was relined and blown in again in September, 1889. The construction was the same in every particular, except that the diameter of the bosh was reduced to 22 ft., and the stock-line to 15 ft. 6 in. The lining runs straight from bosh to stock-line. This change reduced the cubic capacity to 18,200 ft. The same number and size of tuyeres are used. The volume of air blown is 25,000 cub. ft. per min., a reduction of 2,000 cub. ft. from that used in previous blast. The best output for any one week is 2,462 tons. The temperature of blast averages 1,100° and the pressure 9½ lbs. The temperature of the escaping gases is 340°. Counting the time the furnace was running in the first blast, and up to the end of May, 1890, in the second blast, including also the time spent in relining, the period covered is 3 years and 5 months; and in that time this furnace has made an output of 301,205 tons, a record which is unparalleled. The ores used were from the Lake Superior region, and yield through the furnace 62 per cent of iron. The proportion of limestone carried was 28 per cent of the ore burden, and about 1,200 lbs. of cinder was made per ton of iron. The average analysis of the cinder is as follows: silica, 33 per cent; alumina, 13 per cent.

In the period covered by the last decade there are three steps in the development of American blast-furnace practice that might be mentioned: first, in 1880, the introduction of rapid driving, with its large outputs and high fuel consumption; second, in 1885, the production of an equally large amount of iron with a low fuel consumption, by slow driving; and third, in 1890, the production of nearly double that quantity of iron, on a low fuel consumption, through rapid driving. An abstract of the results given by Mr. Gayley is shown in the following table:

Blast-Furnace Practice—Abstract of Results.

DESIGNATION OF FURNACE.	Year in which furnace commenced the blast.	Cubic capacity.	Volume of air per minute.	Total output from blast.	IN FIRST TWELVE FULL MONTHS.			
					Output.	Average daily output.	Average coke consumption.	Capacity for one ton of iron per day.
		Cub. ft.	Cub. ft.	Tons.	Tons.	Tons.	Lbs.	Cub. ft.
Isabella..............	1876	15,000	......	117,575	28,000	76	3,000	197
Lucy No. 2...........	1878	15,400	16,000	92,128	33,552	91	2,850	169
Edgar Thomson, A..	1880	6,396	15,000	......	......	71 *	2,400	90
" " B..	1880	17,868	30,000	112,090	48,179	132	2,859	135
" " D..	1882	21,478	27,000	90,317	65,947	180	2,570	119
" " C..	1885	16,680	31,000 †	118,000	64,998	178	2,677	90
" " D..	1885	18,950	22,000	150,377	74,475	204	2,250	92
" " C..	1887	17,230	24,000	203,050	72,554 ‡	198	2,230	87
" " F..	1886	19,800	27,000	224,795	88,940	244	2,150	81
" " F..	1889	18,200	25,000	......	113,000 §	310	1,920	59

* Estimated. † After running 9 months the volume of air was reduced to 28,000 cub. ft.
‡ The second 12 months, by reason of a continuous blast, show an output of 83,219 tons on 2,396 lbs. of coke. § Estimated from record made to date.
NOTE.—On the completion of the 12 months in blast, the record for furnace F, blast of 1889, shows an output of 413,526 tons, and an average coke consumption of 1,892 lbs.

A Modern Blast-Furnace Plant.—One of the most recent complete blast-furnace plants is that of four furnaces built in 1890 at the South Chicago Works of the Illinois Steel Co., and known as Nos. 5, 6, 7, and 8. The furnaces are built in a line extending east and west, with the cast-houses branching off to the south, and they may be considered as constituting two separate plants of two furnaces each. The individuals of each pair are side by side, and 126 ft. from center to center. Each furnace is 80 ft. high. Nos. 5 and 6 are similarly constructed, each having a bosh of 22 ft., hearth of 12½ ft., and a stock-line of 16 ft. In No. 7 the bosh is 20 ft., but in other respects the lines are the same as in Nos. 5 and 6. No. 8 is considered, so far as the lines are concerned, as quite a radical change from the other three, for its bosh is only 19½ ft., hearth 13 ft., and stock-line 13½ ft., thus showing a tendency to spread out at the hearth and contract in the upper portions. Nos. 5 and 6 are built with five and No. 7 with nine rows of bosh-plates. Each furnace is supported by eight columns 20 ft.

high, and is re-enforced at the hearth with a steel jacket 1½ in. thick by 7 ft. high. Nos. 5 and 6 are furnished with 7-in. bronze tuyeres that extend into the furnace 1 ft. No. 7 has a telescope arrangement for the tuyere, water-jacketed breast, and water-block, all the parts being made of bronze, and so easily adjusted that there is very little delay in replacing them when necessary to make repairs. Each furnace has four Massick & Crooke hot-blast stoves, 22 ft. in diameter and 70 ft. high. They are arranged in a line just north of and parallel to the line of furnaces. Two of each of the four stoves are "on wind" and two "on gas," the change being made every half-hour in such a manner that there is a fresh stove "on wind" all the time. These stoves at present maintain an average temperature of only 1,250° F. to the hot-blast. Directly north of the line of stoves is the stock-yard. Here the coke, ores, and flux are all handled. The coke is unloaded as needed from three rows of trestles placed parallel to the line of stoves, and back of these are three more trestles, from which the flux and ore can be unloaded when necessary. Usually the ore is unloaded directly from the boats on to the docks and taken to the hoists in barrows. It is handled at the docks by 13 Brown hoisting and conveying machines, having an aggregate capacity of 8,000 tons per 24 hours. A double hoist-tower and hoist-engine are placed between each second and third stove. They are the ordinary crane-hoists, and each cage carries two barrows. The harbor was made by dredging, and is 2,600 ft. long by 150 ft. wide, with an average depth of 20 ft.

West of the furnaces are the boiler and engine houses. The former is 87 ft. by 291 ft., and has 40 horizontal tubular boilers 6 ft. by 20 ft. The water used in these boilers and around the furnaces is pumped from the lake. The engine-house is 57 ft. by 250 ft. It is equipped with 10 Southwark blowing-engines, having steam-cylinders 40 in. by 60 in., and 6 cylinders 89 in. by 60 in. The valves are of the regular Porter-Allen link-motion. Two of these engines are held in reserve for contingencies, either one of which can be turned on to any furnace. In the pump-house are 8 compound duplex Worthington pumps, with steam cylinders 29 in. and 18½ in., water-cylinders 18 in. in diameter, and a stroke of 21 in. West of the engine-house is the main water-tank, which is 17 ft. deep and 40 ft. in diameter, and is supplied by means of three centrifugal pumps placed at the lake. In addition to the main tank there are four of smaller capacity, so placed as to be convenient to the furnaces which they are to supply.

The ores smelted by this plant are the hematites of the Lake Superior region. They may be roughly classified as hard and soft ores. In making the mixture, about 15 per cent of the former to 85 per cent of the latter is mixed with a dolomite for the flux, and coke for the fuel. The richest ore will analyze about 62 per cent of Fe (iron), and the poorest will not fall below 50 per cent of Fe. They show on an average about 1·30 per cent of SiO_2 (silica), ·021 per cent of S (sulphur), and ·09 per cent of P (phosphorus). The dolomite contains 1 per cent of SiO_2, 1 per cent of Al_2O_3 (alumina), 53 per cent of $CaCO_3$, and 45 per cent of $MgCO_3$ (magnesium carbonate).

These furnaces are built to make 300 tons of pig-iron each per day. The iron is run from the furnaces into ladles of 12 tons' capacity each, and taken by locomotives to the steel-mill in the liquid state. The cinder is carried off by Weimer cinder-buckets and dumped into the lake before it has time to harden.

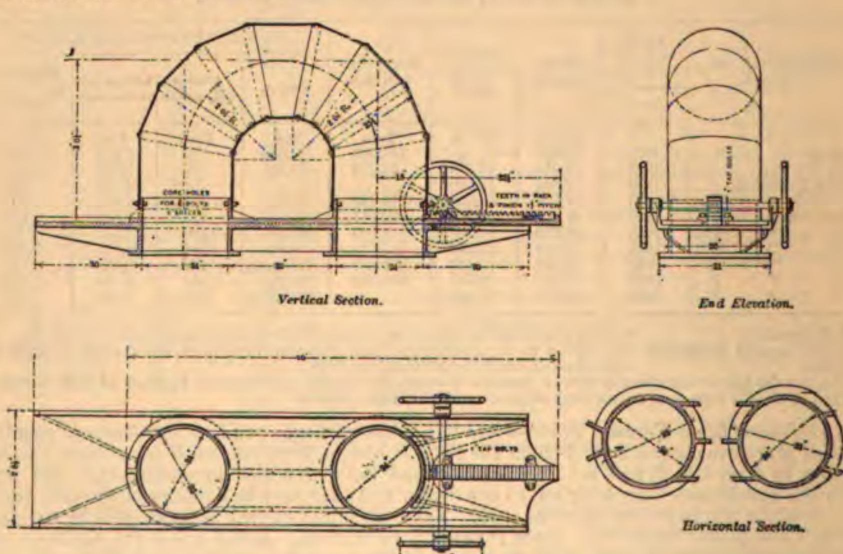


FIG. 2.—The Kennedy furnace.

The Kennedy Gas-regulating and Cut-off Valve.—Hugh Kennedy, of Sharpsburg, Pa., manager of the Isabella furnaces, has designed a gas-regulating and cut-off valve which has been found a very convenient arrangement, since one furnace may be cut off without stopping

the others. In a furnace-plant which comprises several furnaces, it has been found conducive to the regularity of work to cause the gas from all the furnaces to discharge into one main flue, from which the boilers and stoves are supplied. Valves have been placed in the main flue, in order to be able to cut it off from an individual furnace, so that the men can get access to parts where the presence of gas would be dangerous. Owing to the large size of the flues and the necessarily large dimensions of the valves, it has been found difficult to shut off the gas perfectly. Mr. Kennedy, instead of making the flue continuous, divides it by cross-walls into parts corresponding to the number of furnaces, and connects the adjacent parts with each other by removable pipe-connections. The construction of the device is shown in Fig. 2. The U-shaped pipe shown is attached to a plate-casting having holes registering with the openings of the pipe. This plate is set in another plate, and is provided with a rack and pinion, as shown, by which it may be moved longitudinally. The whole is placed on top of the main flue, the partition-wall in which is located between the two openings referred to. A shifting of the pipe and the plate to which it is attached enables the operator to cut off completely the connection between the two adjoining parts of the main flue.

FURNACES, GAS. *Classification.*—The different kinds of furnaces for burning gaseous fuel are thus classified in a paper in the *Proc. of the Inst. of Mech. Eng.*, January, 1891:

Gas-furnaces may properly be divided into four classes, namely: (*a*) with reversing regeneration; (*b*) with continuous regeneration; (*c*) non-regenerative; and (*d*) with blow-pipe or forced blast.

(*a*) Furnaces with reversing regeneration are of several different kinds:

1. The ordinary Siemens furnace, in which both gas and air are heated before admission to the interior of the furnace, by being passed through the well-known arrangement of brick chambers filled with checker-work or loosely piled bricks.

2. The Batho or Hilton furnace, in which the regenerative chambers, instead of being partly or entirely underground, are incased in cylindrical wrought-iron vessels erected upon the ground-level.

3. Furnaces in which the air only is regenerated by being passed through chambers, the gas being admitted direct from the flues by which it arrives from the producers. In these furnaces the whole of the escaping gases or waste heat has to pass through one of the two air-chambers on its way to the chimney.

4. The furnace recently described by Mr. Head (*Iron and Steel Institute Journal*, 1889), in which a portion of the waste heat is taken back to the gas-producer.

5. The various regenerative blast-furnace stoves of the Cowper, Whitwell, and other kinds.

(*b*) In furnaces with continuous regeneration, the air, before admission to the interior of the furnace, is heated in flues or pipes by radiation or conduction from the bottom of the furnace, and through thin walls which separate the air-flues from the flues that carry the spent gases or waste heat to the chimney.

(*c*) In non-regenerative furnaces the air is admitted to the interior of the furnace at its natural or atmospheric temperature.

(*d*) Blow-pipe or forced-blast furnaces are of two kinds: First, those in which the air is supplied at its natural or atmospheric temperature by a fan or blower; second, those in which the air so supplied is heated by the spent gases or waste heat from the furnace, by being passed either through coils or stacks of pipes, or else through brick tubes or flues, as in the case of the Radcliffe furnace and others.

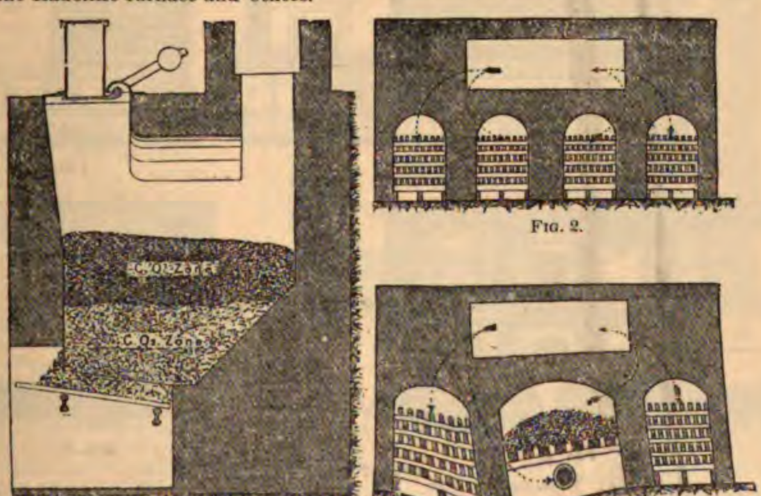


Fig. 2.

Fig. 1. Fig. 3.

Figs. 1-3.—Siemens regenerative gas-furnace.

A New Siemens Regenerative Gas-Furnace.—Messrs. John Head and P. Pouff, in a paper before the Iron and Steel Institute, read in 1889, describe a novel form of regenerative fur-

nace. We extract from their paper as follows: In the new Siemens furnace the gaseous products of combustion from the heating-chamber of the furnace are delivered under the grate of the producer, these gases consisting of intensely hot carbonic acid, water in the gaseous state, and nitrogen. The economy of fuel resulting from the conversion of carbonic acid into carbonic oxide is diagrammatically illustrated by means of the sketch (Fig. 1) of a gas-producer. Assuming that the producer contains only coke in the incandescent state, this coke, if fed with oxygen, will produce carbonic acid in the lower zone, which will be converted into carbonic oxide in the upper zone; but if fed with hot carbonic acid instead of oxygen, one half of the fuel, comprising the lower zone, may be dispensed with, and an economy in weight of fuel to the same extent will be realized. In the new Siemens furnace the waste gases are directed partly through an air-regenerator and partly under the grate of the producer, there to be reconverted into combustible gases, and to do the work of distilling hydro-carbons from the coal; in fact, the gas-producer in this case absorbs or utilizes the heat formerly deposited in the gas-regenerators of furnaces, and in doing this transforms spent gases into combustible gases.

For the propulsion of the gases through the converter a steam-blast is employed. This steam is superheated by the waste gases from the furnace, and, mixing with them, forms a very hot blast under the grate. The diagrams (Figs. 2 and 3) show the relation which exists between the ordinary and the new type of Siemens furnace. The function in both is the same. In the first case the waste gases are partly directed through two regenerators, while in the second case the waste gases are partly directed through an air-regenerator and partly through a converter-producer. In both cases the waste heat from the furnace is entirely

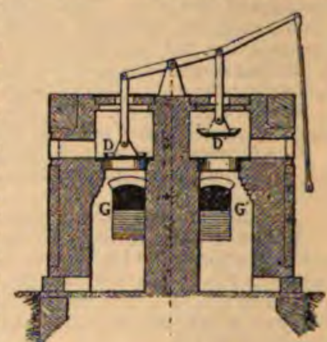


Fig. 6.

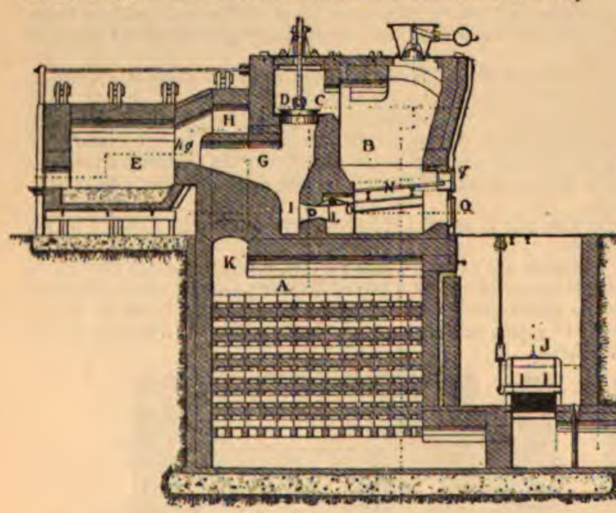


Fig. 4.

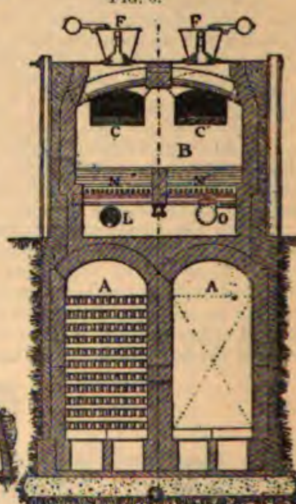


Fig. 7.

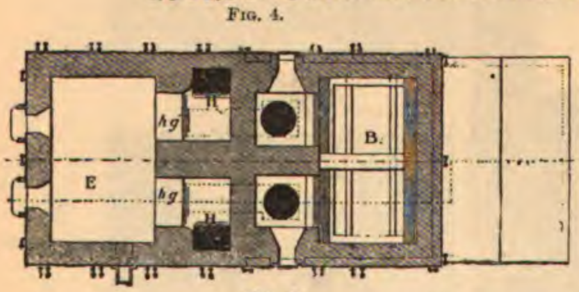


Fig. 5.

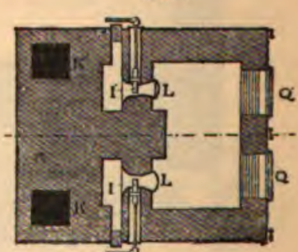


Fig. 8.

Figs. 4-8.—Siemens regenerative gas-furnace.

utilized, and the gas and air reach the furnace in an intensely heated condition. In both cases, again, there is a reversal in the direction of the flame in the furnace, which insures uniform heating of the furnace-chamber and the materials contained in it.

This furnace may be constructed in various forms, that shown in Figs. 4, 5, 6, 7, and 8 having been used with success for heating and welding iron. It is a radiation-furnace, heated

by means of a horseshoe-flame; this form of flame offers advantages in this as in ordinary regenerative gas-furnaces, but its adoption is not obligatory, as the flame may be made to traverse the heating-chamber from end to end in the usual manner. The same letters indicate the same parts in all the figures. A A^1 are reversible regenerators for air, on the top of which is built the gas-producer or converter B, of which F F^1 are the charging-hoppers and N N^1 the grates. The heating-chamber E adjoins the producer resting on the ground, or in some cases a pit may be provided below it. C C^1 are the flues leading the combustible gas to the furnace-chamber E, the passage of the gas in these flues being controlled by the valves D D^1 at the two ends of a rocking beam, so that the outlets are opened and shut alternately to convey the gas to one or other of the ports G G^1 of the heating-chamber E. H H^1 are the air-ports of the heating-chamber, communicating through the flues K K^1 with the regenerators A A^1. I I^1 are steam-jets placed in the return-flues L L^1 for directing a portion of the waste products of combustion to the grates of the converter. J is the valve for reversing the direction of the air flowing into the furnace, and of the products of combustion through the regenerators to the chimney-flue. O O^1 are hinged caps for alternately admitting and shutting off the products of combustion from the heating-chamber to the converter. These caps are worked automatically by means of connections attached to the rocking beam, the same movement which closes D opening O^1, and that which closes D^1 opening O; Q q are doors for giving access to the grates of the converter for clearing them.

The *modus operandi* of the furnace is as follows: Gas from the converter B passes through the flue C^1 and the valve D^1 to the gas-port G^1, and into the combustion-chamber h^1 g^1. Air for combustion passes through the regenerator A^1, the air-flue K^1, and the air-port H^1 into the combustion-chamber, where it meets the gas from the converter, and combustion ensues. The horseshoe-flame sweeps round the heating-chamber E, the products of combustion passing away by the second combustion-chamber h g, and going partly through the regenerator A and reversing-valve J into the chimney-flue, and partly down the flue G, whence they are drawn by means of the steam-jet I through the capped inlet L under the grates of the producer B, there to be converted into combustible gases. From time to time the direction of the flame in the furnace is reversed by manipulating the rocking beam, carrying the valves D D^1 and the reversing-valve J in the usual manner of working regenerative gas-furnaces. An auxiliary steam-jet is provided for the purpose of supplying atmospheric air to start the producer when the furnace is first heated up.

The following advantages are claimed for the new furnace as compared with solid fuel furnaces used for heating and welding iron, viz.: A saving in fuel, amounting to, say, two thirds in weight, after allowing for raising steam in separate boilers, this saving being fully equal to 5 cwt. of coal per ton of iron heated. A reduction in the waste of iron equal to 5 per cent upon the weight of metal heated. A saving in labor and repairs which will probably compensate for the extra cost of the new furnace.

The Pettibone-Loomis Open-Hearth Furnace (Fig. 9).—This furnace is designed for all kinds of open-hearth work using manufactured or natural gas, and is particularly effective with water-gas for very high heats. Gas and air are used under uniform pressure; the former being conducted through the pipes a a' a'' to the burners E, the air passing through the pipes J, where it is heated by the waste products of the furnace, and thence through the pipes b b' to the burners, where the two are thoroughly mixed, delivering a flame of great intensity tangentially into a round furnace. After circulating over the bath the products are taken out near the top of the hearth through the passage F and air-heater C to the stack. The burners are movable, and the flame can be directed on to the bath, or horizontally, as desired. The claims for this furnace are: 1. Low cost and durability. 2. Thorough and active combustion of gas with application of heat to metal by radiation or contact. 3. Character, intensity, and volume of flame under control of the operator. 4. Economy of fuel and certain results.

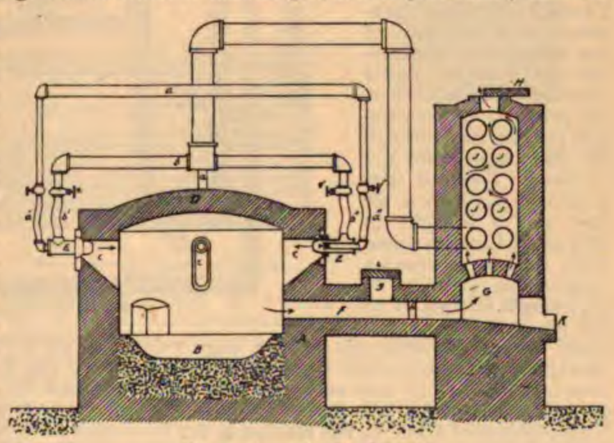


FIG. 9.—Open-hearth furnace.

Gas-Furnace for Melting Metals.—Fig. 10 shows one of many styles of furnace made by the American Gas-Furnace Co. of New York. This style of furnace is in use for gold, silver, copper, and brass, as also for making tests and smaller melts of iron, steel, glass, etc.

The combustion-chamber consists of the bottom A, and the cylinder B, both firmly secured to the distributing-ring C. The burners D penetrate the "bottom" lining A. The bottom is held in position by the iron platform L. The cylinder B is secured to the distributing-ring C by the hinged bolts O. The cover H is hinged to the shaft K, so as to lift clear of the

furnace-top when swung to either side. The "feed-hole" in cover H is sufficiently large to give free access to the crucible without removing the cover, thus confining the heat while feeding the crucible. The small cover I closes the feed-hole. The crucible stands upon a conical fire-brick support. By means of outlets for the products of combustion, both at the bottom and top of the furnace, the greater heat can (in a measure) be made to act either upon the bottom or top of the crucible. When the vent on top is tightly closed, the greatest heat will be below, while the partial opening of the cover I will draw it upward. Air under pressure is supplied through the pipe F. The consumption of gas is according to the quality of the gas and the temperature required. The furnace shown in the cut will require from 200 to 250 cub. ft. of gas per hour, and melt 40 lbs. of copper in 30 min.

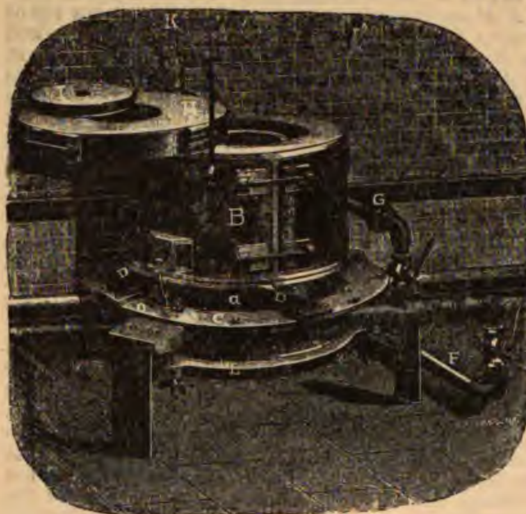


FIG. 10.—Gas-furnace.

The Howe Experimental Regenerative Gas-Furnace. — Mr. Henry M. Howe, in a paper read before the American Institute of Mining Engineers, February, 1890, describes a furnace used by him in experiments on the thermal properties of slags. It was necessary to have command of a very high temperature, at least 1,400° C. (2,552° F.), and to make such dispositions that the platinum-ball used for a pyrometer, and the silicate or silicates experimented on, should be at approximately the same temperature at the moment of withdrawing the former. The regenerative gas-furnace shown in section in Fig. 11 is made with two regenerators, loosely filled with lumps of fire-brick. Through one of the regenerators at a time part of the air used for combustion is brought under pressure from a blower, the products of combustion passing out through the other regenerator and to waste. Common illuminating gas is used for fuel, and is brought in alternately through pipes. With this gas is mixed a considerable quantity of air, brought alternately by the pipes HH'. It was found necessary to thus mix quite a large volume of air with the gas before admitting it into the furnace, to prevent rapid decomposition of the gas with deposition of carbon. At intervals, usually of 5 min. each, the furnace was reversed by means of common three-way gas-cocks. Although only part of the air and none of the gas was pre-heated in this furnace, a temperature of 1,400° C. was reached in it; the hearth of the furnace was made of a molded brick, with depressions for five platinum crucibles NN', and for the platinum-ball M. Crucibles and balls were introduced and removed through the doorway L, closed with a tightly fitting molded wedge-brick.

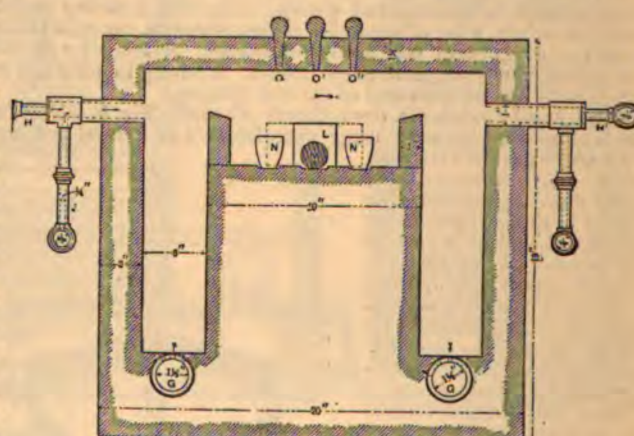


FIG. 11.—Howe gas-furnace.

Refractory Materials for Gas-Furnaces.—Clay fire-brick, of nearly pure silicate of alumina, free from iron, is usually employed in ordinary heating-furnaces, but for the intense heat required in steel-melting furnaces a more durable material is needed. For the roofs of such furnaces silica brick, composed of nearly pure quartz, with from 1 to 2 per cent of other materials, chiefly lime and alumina to give binding quality, are used. For the basic open-hearth furnace there is required a material which will not be acted upon by the basic slag, and at the same time will withstand the highest temperatures. Such a material is magnesite brick, made from carbonate of magnesia, and containing when burned about 90 per cent of magnesia and 10 per cent of silica and oxides of alumina and iron.

FURNACES, PUDDLING AND HEATING. *The James Puddling-Furnace* is shown in Fig. 1. It has a hollow fire-bridge *C*, with a transverse flue *K*, from which a number of orifices, *c*, lead upward. The air is preheated in the flue *P*, which connects, as shown, with the space *E* in the fire-bridge under the fuel-chamber *A*, and the grate-bars *a* is an air-chamber *D*, formed by a tight box *d*. Leading into this air-chamber are a number of air-pipes *e*, into the bell-shaped mouth of which the nozzles of steam-pipes *f* are projected, so that the steam draws in air. Above the bridge is a cold-air flue *g*, connected with a number of openings with the furnace above the fire-bridge. It is provided with a valve to regulate the admittance of cold air when required. While in the ordinary type of puddling-furnaces the consumption of good Pittsburgh coal was 2,200 lbs. at the Arethusa Works, Newcastle, Pa., with the James modifications the consumption was but 1,800 lbs. with the same coal. Similar results were attained in the heating-furnaces of the plate-mill.

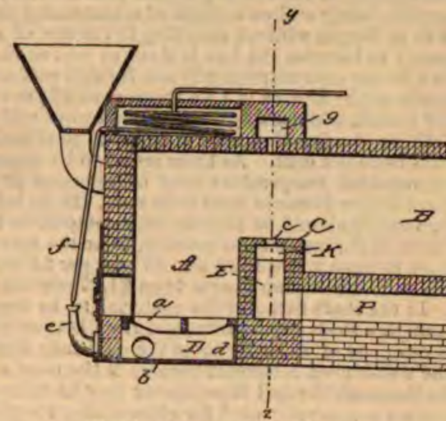


FIG. 1.—James puddling-furnace.

The Stubblebine Heating-Furnace is shown in Figs. 2, 3, and 4. It has been introduced in the Bethlehem and Catasauqua (Pa.) rolling-mills. The gases from the furnace are split when issuing from the reverberatory chamber into three parts, the one passing through the up-take through the stack. On either side thereof two flues lead to two heating-chambers, in which are placed coils of pipe through which air is blown and in which it is

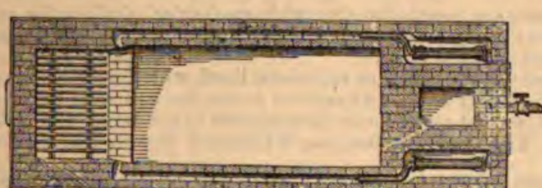


FIG. 2.

FIG. 4.

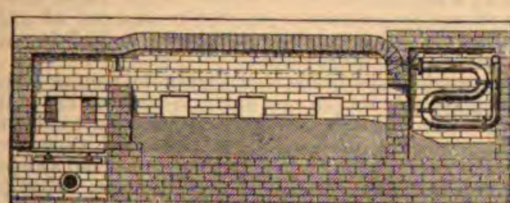


FIG. 3.

FIG. 2-4.—Stubblebine furnace.

preheated. The heated air issues from two nozzles into mixing flues in the side walls of the furnace. In this manner the gas in the preheating chambers is drawn by the suction created into the mixing flues, which discharge them into the flame at the fire-bridge. The furnace works well on billets, and on large or small fagots. It heats quickly, and the flame is under such control that the waste by oxidation is very low.

FURNACES, ROASTING. Roasting-furnaces are either oxidizing or chloridizing, according as the purpose for which they are used is to convert the metals in the ores treated to oxides or chlorides. There are six kinds of roasting-furnaces in common use, viz.: kilns, muffle-furnaces, reverberatory furnaces (Fortschaufelungsofen), shaft-furnaces, mechanical hearth-furnaces, and cylindrical furnaces.

Reverberatory furnaces, which are most commonly used for calcining fine ores, consist of a long brick hearth, with a low roof, and a series of small doors on one or both sides. At one end of the hearth is a fire-box, and at the other a flue connecting with the chimney, a dust-chamber usually being interposed. The fine ore to be roasted is fed in through a hole in the roof at the flue end, and is gradually worked forward toward the fire-box end by men using long rabbles through the doors in the sides. The flames from the fire-box draw over the ore toward the flue, the low roof throwing them down on to the ore. The roasted ore is pulled out of the furnace through the doors next to the fire-box. Reverberatory furnaces are frequently built with two hearths, and sometimes three or four, placed one above the other, the flames drawing successively through each. The object of this arrangement is obviously to

increase the length of the hearth, and its utility is determined by the character of the ore to be roasted. The length of the hearth, according to Dr. E. D. Peters, Jr., is limited chiefly by the capacity of the ore to generate heat during its oxidation, the immediate influence of the fireplace being seldom capable of maintaining the requisite temperature upon a hearth over 16 ft. in length without resorting to the use of a forced blast, or of a draft so powerful as greatly to increase the loss in dust, as well as the consumption of fuel. An ore carrying less than 10 per cent sulphur will not furnish sufficient heat to warrant the addition of a second hearth to the first 16 ft.; an increase to 15 per cent will be sufficient, however, to heat a second hearth, while a 20 per cent sulphur-ore will work rapidly in a three-hearth furnace. The addition of a fourth hearth is rendered justifiable by the increase of the average sulphur contents to 25 per cent. As there seems to be almost no limit to the extent of surface over which the requisite temperature may be obtained in the calcination of highly sulphureted ores, much longer furnaces have been used, 120 ft. being the extreme inside limit. The width of the furnace should be as great as is compatible for convenient manipulation. Experience has shown 16 ft., inside measurement, to be the extreme limit. The capacity of a large reverberatory furnace varies from 6 to 16 tons per 24 hours, depending upon the character of the ore. The cost of calcining ranges from $1.25 per ton upward.

In the shaft-furnaces the material to be roasted is allowed to fall as a shower of dust through a shaft that is traversed from bottom to top by the flames from a lateral fireplace. In one class of shaft-furnaces the dust falls freely; in others there are obstacles in the way. The well-known Stetefeldt furnace is the most successful furnace of the open-shaft class, and the Gerstenhöfer and Hasenclever may be taken as types of the latter class. The Stetefeldt furnace is generally used for chloridizing roasting, but experiments have shown that it may be also an efficient oxidizing furnace, although it has not yet come into practical use for that purpose. The capacity of the Stetefeldt furnace, according to Mr. C. A. Stetefeldt, is from 35 to 80 tons per 24 hours. If the ore is so base that 75 or 80 per cent of it is in the form of sulphurets, 35 tons is the maximum limit for really good work. In most cases, however, where the ores contain only a moderate percentage of sulphurets, a large furnace will easily handle from 60 to 80 tons per 24 hours, but the latter figure is probably the economical limit.

The mechanical hearth-furnaces are hearth-furnaces with mechanical devices for raking or stirring the charge. They have circular hearths, rotating under fixed rakes; or fixed hearths, either circular or rectangular, and movable rakes.

The cylindrical roasting-furnaces are cast-iron cylinders, lined with fire-brick, through which the flame draws from a stationary fire-box at one end to the flue and dust-chamber at the other. The charge is stirred, so that all its parts are subjected to the action of the flame, by the rotation of the cylinder. The Brückner, Douglas, White, and Howell-White furnaces are types of this class.

The cost of roasting varies with the character of the ore, the kind of furnace, and the cost of fuel and labor. The lead-smelters at Denver, Col., roast ore in reverberatory furnaces at an average cost of $2 per ton. With a mechanical hearth-furnace at the Haile mine, North Carolina, pyrites concentrates are roasted preparatory to chlorination at a cost of $2.62½ per ton. Under favorable circumstances, pyrites concentrates have been roasted in the West, even where labor and fuel is high, for as low as $1 per ton.

KILNS.—The ordinary type of roasting-kiln is too well known to require description. They are, obviously, used in roasting coarsely broken ores only. A modification of the common kiln which is in general use for calcining iron-ores may be termed shaft-kilns, working upon the same principle as shaft-furnaces—i. e., the ore being desulphurized while descending through a rising current of flames, but, as in the kilns, the ore is in coarse lumps and is made to descend slowly rather than in a shower of fine ore as in the shaft-furnaces. The Gjers kiln and the Davis-Colby roaster are furnaces of this class.

The Gjers kiln, extensively used in calcining iron-ores, is a circular shaft-furnace built of fire-brick cased with malleable iron plates. The bottom of the brick-work rests in a cast-iron ring, and the whole is supported by cast-iron pillars about 2½ ft. high, leaving a clear space between the bottom of the kiln and the floor. The latter is covered by iron plates, in the center of which is fixed a cast-iron cone 8 ft. in diameter at the base and 8 ft. high, extending up within the shaft. Around the lowest tier of plates incasing the kiln are openings which are usually closed by doors, but which serve for admission of air or tools in case the ore becomes sintered. The ore, mixed with a proper proportion of coal, is fed into the furnace at the top, which is surrounded by a gallery for the workmen. The roasted ore descending is caused by the interior cone to pass outward at the bottom of the furnace. These furnaces are usually 33 ft. in height; at the base they are 18 ft. in diameter, widening to 24 ft. 10 ft. higher up. The upper part of the kiln is cylindrical, and 24 ft. in diameter. A kiln of this size has a capacity of about 8,000 cu. ft., and calcines about 115 tons of iron-ore per 24 hours, the consumption of coal amounting to 1 ton for 25 tons of ore.

The Davis-Colby Ore-Roaster, which is also much used for desulphurizing iron-ores, consists of a circular hollow shaft with walls about 2 ft. in thickness, in which are located fire arches fed with gas, which gas may be taken from any source—gas-producers, natural wells, or the waste-pipes of blast-furnaces. The gas-mains enter flues built in the masonry directly over the fire arches, and the gas is drawn through openings left in the top or bottom into the arches, where it takes air and is consumed—the resulting flames being drawn directly into and through the ore. In the center of the kiln there is a smaller hollow shaft, starting from the bottom and extending up through the entire portion of the kiln and terminating in the draft-stack—

being, in fact, the draft-stack itself. In the walls of this central shaft, and opposite the fire arches, are a series of openings through which the products of combustion are drawn directly into the stack and discharged so that the heat from the burning gases is drawn across a narrow body of ore instead of up through the overlying mass, and the liberated sulphur allowed to pass off directly. There may be any number of rows of fire arches, and below each of these is a row of openings for admission of air.

The latest form of these roasters is 30 ft. in height, and 17 ft. diameter at bottom and 14 ft. at top, with the central flue terminating in a draft-stack 48 in. in diameter. The ore is dumped into the top of the kiln and occupies the annular space between the two walls. Descending by gravity, it first meets the current of gas from the upper set of fire arches and gets a preliminary drying and warming. Passing thence before the next and lower arches it gradually reaches a red and even white heat, every part of the ore rolling and turning over in its passage, and being subjected while highly heated to drafts of air, the liberated sulphur passing directly off into the central stack. The annular space, being 14 in. at the top and gradually increasing to 29 in. at the bottom, gives opportunity for constant moving of the ore and decreases the chances of its adhering to the walls. The roasted ore is drawn through chutes directly into bins, barrows, or conveyers. The discharge of ore is regulated by drawing from the chutes, and the heat by varying the amount of gas. The furnaces vary in capacity, according to the ore. At the Croton mines, Brewster, N. Y., from 200 to 300 tons per day are said to be run through each furnace. Mr. W. H. Hoffman (*Trans. A. I. M. E.*, October, 1891) thus describes the practice there: "A series of experiments was made to determine the best size for economical roasting (the ore containing 2 per cent sulphur), and at the end of three months a size that would pass through a 2½-in. ring was adopted as giving the most rapid work for the quantity of fuel consumed. Crude Lima-oil is used for roasting, the furnaces being remodeled for this purpose. Through experiments conducted by our general foreman, Mr. T. Blass, we found the average consumption of fuel-oil to be 3·75 gals.; but by enlarging the combustion chambers we have reduced this amount to a little over 3·6 gals. per ton of raw ore. The cost of the oil is 2¼ cents per gal., making a fuel cost of 8¼ cents per ton of raw ore. The labor of filling and discharging amounts to only 3 cents per ton, as this work is largely automatic. The average temperature is 1250° F., and the ore is roasted down to about 0·5 per cent sulphur."

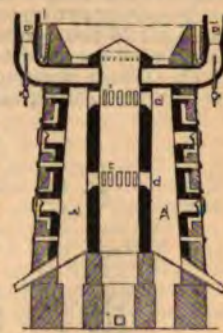


FIG 1.—Roasting-furnace.

A modification of this type is shown in Fig. 1, in which the draft-stack is cut off and surmounted by a bell, the draft being downward and outward at the bottom of the kiln. In this case the ore is dropped from self-dumping cars directly on to the bell which distributes the charge, and falling by gravity is drawn directly into the furnace barrows, thus avoiding all handling of ore from the mine to the furnace-top.

MECHANICAL HEARTH-FURNACES.—*The Rotary-Pan Furnace* (Fig. 2) used at the Haile mine, North Carolina, for roasting fine pyrites for chlorination, is a combination of the reverberatory furnace with the mechanical hearth-furnace. It is a reverberatory furnace with step-hearths and a circular rotating hearth at the fire-box end. The charge is fed at the flue end and gradually worked forward by hand to the circular hearth, where the roasting is fin-

FIG. 2.—The rotary-pan furnace.

ished. Thies and Phillips (*Trans. A. I. M. E.*, xix, 601) give the capacity of this furnace, roasting pyrites concentrates, as 3½ tons per 24 hours. A double-hearth reverberatory furnace with 400 sq. ft. hearth area, at the same place and with the same ore, desulphurizes 2¾ tons per 24 hours. Each furnace consumes ¼ cord of wood per ton of roasted ore, and requires the labor of 4 men, which is not very good practice compared with what is done with single-hearth reverberatory furnaces in the West.

The Spence Automatic Desulphurizing Furnace consists of a series of hearths placed one above another, with a mechanical device for raking and stirring the charge on each. Each hearth has an opening at alternate ends, through which the charge drops to the next hearth below. On each hearth there is a rake of nearly the same width as the hearth, which is moved backward and forward from end to end of the furnace by a rod working through a stuffing-box at one end. The ends of the rods outside the furnace are supported by a rack or carriage which travels on a railway. The necessary supply of air is admitted through adjust-

able ports below the lowest hearth. The number of hearths varies from three to seven, according to the character of the ore to be roasted. Connected with the furnace is a pair of 7 × 10 engines, which run at 40 revolutions per minute, and quietly and positively operate by means of geared wheels the rods to which the toothed rakes in the furnace are attached. The charge is raked at intervals of about five minutes, and in the mean while the rakes are pulled to the back end of the furnace and the driving-engines are stopped. Connected with the furnace there is also a small auxiliary engine, which runs constantly, and by suitable mechanism puts the large engines and rakes in operation at the proper times. The ore is fed into a hopper on the top of the furnace, and is gradually admitted to the latter through a port which is opened and closed by the movement of the rakes. Falling on to the uppermost hearth it is gradually worked along until it drops through the hole to the next hearth below, when it is worked backward, dropping on the third hearth, and so on. From the lowest hearth it is discharged into a bin or cars, through a port which is also opened and closed by the movement of the rakes. When the rakes have finished the forward stroke the engines reverse automatically, and the rack returns to position and stops until the auxiliary engine puts the driving-engines in operation for another cycle. This furnace was especially designed for roasting fine pyrites for the manufacture of sulphuric acid, and has given excellent results in that work, fine ore with from 40 to 47 per cent sulphur having been desulphurized to 1·5 to 2·5 per cent sulphur, at the rate of from 7½ to 10 tons per 24 hours. In roasting pyrites for sulphuric-acid manufacture no extraneous fire is used, the pyrites itself burning freely on the lower shelves. In roasting fine auriferous pyrites down to ¼ or ½ per cent sulphur preparatory to chlorination, a fire-box connected with the lowest shelf is used with the furnace. At the Treadwell mill, Douglas Island, Alaska, six Spence furnaces were used for desulphurizing pyrites concentrates for chlorination, with the result that slightly more than 3 tons per 24 hours were roasted "dead," with an expenditure of ⅛ cord of wood per ton of ore. Two men per shift attended to six furnaces.

The O'Hara Roasting-Furnace (Fig. 3) is a mechanical reverberatory furnace made with two separate hearths, one for desulphurizing and the other for chloridizing the ore, both

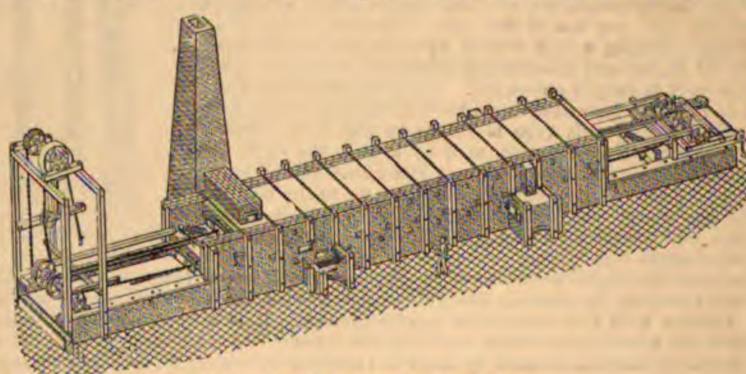


FIG. 3.—The O'Hara roasting-furnace.

processes being performed at one operation. Attached to an endless chain at proper distances apart are iron frames formed into a triangular shape; on these frames are a number of plows or hoes set at an angle. One set turn the ore toward the center, the next set turn it in an opposite direction toward the walls. These plows move through the ore every minute and expose a new surface of ore to the flames and gases. The space between the roof and hearth of each compartment is quite small, so as to confine the heat close to the ore. The operation of this furnace is as follows: The ore is fed continually into a hopper, through which it then falls on the upper hearth. The plows, actuated by the endless chain, stir the ore over and over on the hearth and move it gradually to the opening, where it falls to the lower hearth. As the ore is passed along in the upper compartment it is thoroughly desulphurized by the heat furnished by the fires, as described, and by the combustion of the sulphur in the ore. This action is assisted by the oxygen in the supply as admitted at intervals through the sides of the furnace by the openings. For a chloridizing roasting salt is mixed with the ore as it is fed into the hopper, and becomes thoroughly intermingled with it by the stirring action of the plows. When the ore falls through the opening and on to the lower hearth the fall breaks any spongy lumps or masses that may have been formed, and the ore is again stirred over and over, and moved along through the flame and gases over the lower hearth by the action of the plows toward the discharge-opening. The ore has become gradually more and more heated in its passage through the upper hearth, and by the time the extra heat is required as stated it comes immediately in front of the same fires which have during the whole process furnished the heat. Ordinarily the ore will be from five to ten hours in passing through the furnace, according to its character. Only one man is required to attend the fires, no other attention being necessary, as the ore may be fed to the furnace by mechanical means, and discharged from the furnace into a car, conveyer, or elevator. This furnace is also used with excellent results for oxidizing roasting.

CYLINDRICAL FURNACES.—*The Improved Brückner Roasting-Cylinder*, extensively used both for oxidizing and chloridizing roasting, consists of an iron cylinder, lined with fire-brick, and provided with two receiving and discharging doors midway in its length, which come directly under the charging hopper, and discharge directly into an iron hot-ore car placed underneath, or, if desired, into a pit. The cylinder revolves on four rollers, and is caused to rotate by spur gear-wheels driven by a worm-gear and pulleys. At one end of the furnace is an iron fire-box, mounted on brick foundations, and having a conical opening to match that on the cylinder, which is alike in form at both ends, the other end revolving close to the flue-opening. The furnace and its conical ends (throats) are lined throughout with fire-brick. Being of smaller diameter at the ends than at the center, the ore is thrown to and fro, changing its position frequently, and exposing new surfaces and particles to the action of the flames which draw through from the fire-box at one end to the flue at the other. These cylinders are commonly made in two sizes, viz.: 6 ft. diameter by 12 ft. long, weighing 15,000 lbs., which have an average capacity of 3 to 4 tons of ore; and 7 ft. diameter by 18 ft. long, weighing 28,000 lbs., with an average capacity of 6 to 8 tons. In the latest form of these cylinders the fire-box is really a car, running on a track at right angles to the longitudinal direction of the cylinders, and having a short flue in one side that comes exactly opposite the throat of the furnace. In this way the fire-box can be run opposite a cylinder which contains a fresh charge, and fired on until the sulphur is fairly kindled. Then the movable fire-box may be wheeled along to a neighboring cylinder, and the first one left to complete combustion of the sulphur with free access of air, and undisturbed by the reducing gases that pass up from an ordinary grate. After combustion of the sulphur it is necessary for a perfect roast to again connect the fire-box with the cylinder, and supply a little extraneous heat to complete the decomposition of the sulphates. It is estimated that two horse-power are required to drive a charged cylinder at an average speed. At the smelting-works of the Anaconda Mining Company, Anaconda, Mont., 156 Brückner cylinders are in constant use, desulphurizing ore containing about 35 per cent sulphur. The average charge is 9 tons, which in 24 hours is roasted down to 10 per cent sulphur, or in 36 hours to 3 per cent. For each cylinder 1 ton of Rock Springs coal (much inferior to that of Pennsylvania) is required per 24 hours. Two men attend to three furnaces. Dr. Peters states that the saving in cost in Butte, Mont., by using Brückner cylinders rather than reverberatory furnaces amounts to 40 per cent. Mr. R. H. Terhune states (*Trans. A. I. M. E.*, xvi, 18) that the best results obtained with the Brückner cylinder, 7 × 18 ft., with 4 in. brick lining, oxidizing roasting, at the Germania Smelting Works, near Salt Lake City, Utah, was the desulphurization of a charge of 8 tons down to 4 to 6 per cent sulphur, in 24 hours. The amount of fuel used (Pleasant Valley coal) was 20 per cent of the charge, and two men per shift of 12 hours attended to three furnaces. A cylinder 7 × 22 ft. in size was subsequently introduced at these works, and its results led Mr. James, the superintendent, to believe that the economic length of the Brückner furnace had been reached at 22 ft.

Arent's Improved Brückner Cylinder differs from the preceding in the shape of the roasting-chamber, which is not a true cylinder, but is made in the shape of a frustrum of a cone, its base being turned toward the fireplace. In this frustrum of a cone the ore seeks the same horizontal level when revolved around its axis as in the Brückner, and is thus forced to form a layer of graduating thickness in the chamber, with its thin end near the flue end and its thickest or deepest end toward the fireplace. The flame coming from the fireplace is, of course, hottest at that end; and there, in this furnace, it finds the most ore to heat. As the flame, in its passage through the roasting-chamber, loses in intensity, so the ore layer becomes thinner; and there is less and less ore to heat until the flue is reached. In this manner it is claimed that the charge is "done" simultaneously at all points throughout the roasting-chamber. This cylinder is usually made 18 ft. 6 in. long, 7 ft. 3 in. outside diameter at the large end, and 6 ft. 3 in. at the smaller end.

The White Roasting-Furnace (Fig. 4) consists of a long cast-iron revolving cylinder inclined toward the fire end, and fed at the upper end with crushed pulp from stamp batteries

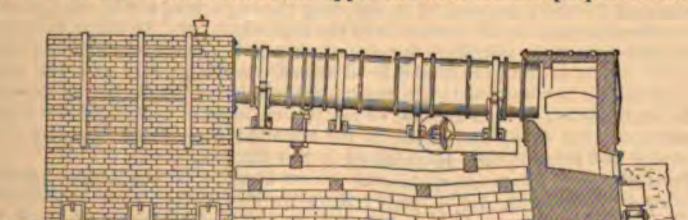


FIG. 4.—The White roasting-furnace.

or other pulverizer. The cylinder is made in sections to facilitate transportation. It is supported on four wheels or rings resting on truck-wheels and guided in a central position by rollers in upright frames, and revolved by friction of truck-wheels through gears and pulleys. The angle of inclination is changeable. The cylinder is lined with fire-brick throughout, and projecting bricks raise portions of the pulp and drop it through the flames, assisting the process. Salt for chloridizing is added before the pulp enters the cylinder. The advantages claimed for this furnace are that it is continuous in its operation,

discharging its product regularly into a pit at the lower end, and this roasted pulp need be withdrawn only as required; also that it submits the ore to a gradually increasing temperature, which is the true theory of perfect roasting. By changing the inclination, the ore can be retained to a longer or shorter period as necessary. The furnace is commonly made in three sizes, as follows: 40 in. by 24 ft., capacity 15 to 20 tons; 52 in. by 27 ft., capacity 20 to 30 tons; 60 in. by 27 ft., capacity 30 to 45 tons.

The Howell-White Roasting-Furnace is designed and works upon the same principle as the White, but has an auxiliary fireplace at the flue end, through the flames of which the dust from the roasting ore is drawn, and much that would otherwise pass off unoxidized or unchloridized is thereby roasted. The larger part of the cylinder at the fire end is lined with fire-brick, leaving the metal on the smaller portion exposed, as the greatest heat takes effect at the fire end. Cast-iron spirally arranged shelves assist in raising and showering the pulp through the flames. This furnace is fed in somewhat the same manner as the White, and is made in the same sizes, its capacity also being about the same.

Hofmann's Roasting-Furnace is an improved revolving cylinder furnace, with a fireplace and flue at each end. The flues are between the fireplace and cylinder, descending to the dust-chambers, which are connected with the main flue. The arrangement is alike on both sides. By means of dampers the current of the air and gases can be made to pass through the furnace in either direction. The object of this double fireplace arrangement is to enable the operator to expose the charge of ore to a uniform temperature. The fire is kept first on one place, with closed dampers on the same side, while the flue connection on the opposite side is open. After a few hours a fire is built in the other fire-box, and the position of the dampers is reversed. By changing the fire once or twice during roasting, both halves of the charge are exposed to the required temperature, without overheating one portion of the charge, thus, it is claimed, producing a higher and more uniform chlorination and diminishing the formation of balls. This furnace is especially suitable for ores which either require a very low roasting temperature or a very high one. By closing one of the large dampers near the main flue and opening the damper of the descending flue and corresponding plug-door, a current of live air can be made to enter the furnace together with the flame, thus assisting the combustion of the fire-gases and the oxidization of the ore. It is apparent that this arrangement permits the construction of cylinders of larger capacity than it is practical for furnaces with only one fireplace.

The Douglas Roasting-Furnace is a revolving cylindrical furnace with a fixed flue within the cylinder. The ore to be roasted is charged within the annular space between the outer shell and the central flue, through which the flames draw, as in the Brückner, White, and other furnaces of this class. This arrangement constitutes a revolving muffle, in fact, and it is claimed, makes a more efficient oxidizing furnace, as in the ordinary cylinder the flames, coming in direct contact with the ore, have a reducing action for a time after each firing. This evil effect is felt more in the cylinders, which are closed from end to end, than in the ordinary reverberatory furnace, which is furnished with a large number of side openings, by each of which more or less air enters to maintain oxidation. In the Douglas furnace the admission of air to the roasting ore is regulated by a register at the discharge end. The loss of heat by its transmission through the walls of the flue is trifling. The degree of heat required, even at the fireplace end of the cylinder, is small, and but very little of this escapes into the chimney after its passage through a flue of 30 ft. or so in length.

The central flue may be constructed of cast-iron pipe, supported by spiders, and the ore be agitated by shelves, as in the ordinary cylinder, but a square or triangular tile-flue, supported by heavy tiles built into the lining, is preferable. If the tiles be of good material and well locked together in the cylinder, the flue and its supporting shelves can not work loose or fall to pieces. Such a cylinder is converted into three or four muffles, and the ore is agitated by a gentle rolling motion, which, it is claimed, is preferable to the pounding action to which the particles are exposed when dropped from shelves, and which case-hardens them during the plastic state through which most ores pass in the early stage of roasting. Another advantage claimed for the flue consists in reducing the current of air in contact with the ore, and therefore the amount of dust carried into the dust-chamber. In order to burn the combustion gases, and supply the necessary surplus of oxygen to the ore, the amount of air and gas striking the ore in the ordinary cylinder is necessarily much greater and the current more rapid than that which is admitted to the roasting compartments only of the flue-cylinder.

An ore liable to sinter, such as galena, or matte rich in lead, as well as the higher grades of copper matte, can not safely be roasted in the confined inaccessible space of the cylinder; but all other ores and products can be calcined in this furnace.

Works for Reference: *Roasting Gold and Silver Ores*, by Guido Küstel, 1880; *Leaching Gold and Silver Ores*, by C. H. Aaron, 1881; *Metallurgy of Silver, Gold, and Mercury in the United States*, by T. Egleston, vol. i, 1887, vol. ii, 1890; *Metallurgy of Gold*, by Manuel Eissler, 1891; *Metallurgy of Silver*, by Manuel Eissler, 1889; *Modern American Methods of Copper-Smelting*, by E. D. Peters, Jr., 1891; *The Lixiviation of Silver Ores with Hyposulphite Solutions*, 1888; *Chloridizing, Roasting, and Lixiviation at Yedras*, by George J. Rockwell, *Engineering and Mining Journal*, February 4, 1888, *et seq.*

FURNACES, SMELTING. Smelting-furnaces may be divided into three general classes, i.e., shaft-furnaces, reverberatory furnaces, and retort or closed-vessel furnaces. In furnaces of the first class the charge and fuel are in intimate contact, there being no independent hearth or fireplace. In furnaces of the second and third classes the fuel and ore are kept separate, the fuel being burned on an independent hearth. The Bessemer converter, used in

steel-making, and the Manhés converter, used in copper-smelting, are omitted from t… fication. In lead-smelting in this country shaft-furnaces are invariably used; i… smelting, shaft or reverberatory furnaces, according to the character of the ore, employe… shaft-furnaces used for the reduction of iron-ores are described elsewhere (see F… BLAST). For the reduction of zinc and quicksilver ores retort-furnaces are employ…

The shaft-furnaces used in lead and copper smelting are known as Pilz furnac… horizontal section is circular, or Raschette furnaces if it is rectangular. Pilz fu… now very little used. Although the circular form possesses certain advantages, expe… shown that the ordinary blast used in lead and copper smelting, seldom exceedin… sq. in., can not well penetrate to the center of a charge in a furnace of greater dian… 50 in. The size, and consequently the capacity, of a Pilz furnace are therefore limi…

The general construction of the Raschette furnace, which is used in lead-smeltin… in Fig. 1. The crucible, resting upon a solid foundation, is built of fire-brick and… fire-clay, the whole being surrounded by a curb of thoroughly braced wrought-iron plates. Upon the brick-work within the curb is placed the water-jacket, which is make of wrought-iron boiler-plate in four parts, two side and two end pieces. It is so constructed that no seams appear next to the fire, and all four parts are bound by wrought-iron forgings, which can be quickly unfastened when necessary. Cast-iron spouts are riveted to the jackets for overflow and feed water. Hand-holes are also provided for cleaning out sediment, and in the side jackets are openings for the tuyères, the number of which vary with the size of the furnace. Four iron columns, resting upon the foundation of the furnace, support the brick-work above the water-jacket, the brick-work resting upon a deck-frame of wrought-iron I-beams, united by wrought-iron plates and bolts. Angle-iron corner-binders hold the brick-work against all cracking. The slag-spout is shown at the end of the furnace, the lead-well at the side, and the charging door just above the upper floor.

The furnace is surrounded with a large pipe of galvanized iron, called the bustle-pipe, to receive the air-blast from the main blast-pipe and distribute it to the tuyères. The bustle pipe is connected with the tuyères by flexible pipes, usually made of canvas. The tuyères are short, conical iron pipes pointing into the furnace, passing through the water-jacket. The outer ends of the tuyères can be opened, so that a rod may be inserted to clear them of slag if they should become thus clogged. The furnace shown in Fig. 1 is equipped with the Devereux adjustable tuyères. These consist of a loose iron sleeve, cast with a central bore at a considerable angle, and capable of being quickly revolved by the hand to point the blast up or down at any angle between the extremes. The tuyère rests in the tuyère-hole formed by a bronze-metal tube in the water-jacket, and is thus cooled.

FIG. 1.—Raschette furnace.

The average size of the Raschette furnaces used at Denver, Col., where the practice of lead-smelting has been carried to a higher degree of perfection than anywhere else in the world, is 33 in. wide and 100 in. long. The average amount of ore smelted in these f… naces is 40 tons per 24 hours. The largest furnace in use is 60 in. wide and 120 in. long, … water-cooled tuyères protruding 6 in. on either side. The capacity of this furnace is 80 to… per 24 hours. The average cost of smelting in Denver is $4.75 per ton, excluding the cost … roasting, which amounts to about $2 per ton. I am indebted to Prof. H. O. Hofman, of th… Massachusetts Institute of Technology, for the foregoing figures.

The general construction of the Raschette furnace used for smelting copper-ores is simil… to that used for lead, the main point of difference being the crucible. For the reduction … oxidized ores furnaces with an interior crucible are generally used. Fig. 2 shows a furna… of this type, 33 in. wide at the tuyères and 66 in. long, designed by Carl Henrich for th… Detroit Copper Company's smelting-works at Morenci, Arizona. It consists of a lower an… an upper water-jacket of wrought iron, the lower one supported from the cast-iron botto… plate and short columns, the upper one resting upon four long columns by means of cast-ir… lugs or brackets. Between the lower jacket and bottom plate is a wrought-iron curb, co… fining the metal crucible, which is formed with fire-clay. Above the upper jacket is a sho… sheet-iron casing, extending to the charging floor and lined with one thickness of fire-bric… and containing the outlet for connection to dust-chamber. A floor-plate of cast iron is pr… vided with inside hoppers. The stack is of telescope pattern, the stationary part being pr… vided with roof-plate and umbrella, while the movable part is provided with balance-weigh… that permit pushing it up out of the way when the furnace is in operation, and allows it … be quickly lowered when blowing out. Two water-jackets are introduced to provide a wat… cooled surface from crucible to the top, in order to do away with brick almost entirely. B…

upper and lower jackets are made in four sections (two side and two end pieces). There are fourteen tuyères, five in each lower side jacket and two in each lower end jacket. Two distinct sets of water-pipes are provided for water supply and discharge. A galvanized bustle-pipe surrounds the furnace, and connection to tuyère elbows and nozzles is made by canvas hose. The tuyère elbows or nozzles are provided with a ball-end, which makes a universally adjustable joint in the tuyère, which is made to suit it.

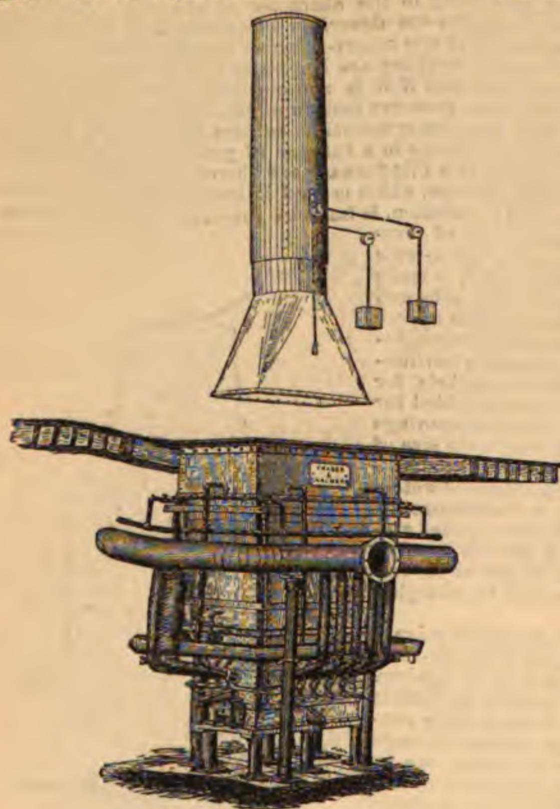


FIG. 2.—Raschette furnace.

The cross-section of this furnace at the tuyères is 33 × 66 in., while 10 in. higher up a bosh is begun, so that 30 in. above the tuyères the cross-section is enlarged to 45 × 78 in. The four lower cast-iron jackets terminate at this point, where they are surmounted by the other four, which still diverge slightly, so that at their upper surface, 7 ft. 6 in. above the tuyères, the furnace has an inside section of 54 × 87 in., which is retained to the charging door, 10 ft. 6 in. above the tuyères. The slag top is 6 in. below the latter, and the crucible is 14 in. deep, lined with brick, and provided with a drop bottom. The object of the bosh is to increase the reducing action, with the view of obtaining cleaner slags.

In smelting sulphide ores the American practice of the present day is to do away entirely with the ordinary deep crucible, substituting for it merely a sloping bottom a foot or less below the tuyères, from which the entire molten material escapes through a narrow groove under the breast, then first entering an outside crucible or well, in which the matte separates from the slag and is tapped into molds, while the slag flows from a spout into iron pots arranged on wheels for convenient dumping. In this manner, chilling over the metal in the crucible and the troublesome freezing of the tap-hole are avoided. The formation of sows is also prevented by the immediate escape of the fused ore from the powerful reducing action of the fuel. Provision is made to prevent any escape of blast under the breast, either by so thoroughly covering the orifice and channel that only a minute groove exists, which is constantly filled to its utmost capacity with molten ore, which soon forms an impervious cover to its channel; or by so raising the terminal slag-spout, and lowering the anterior wall of the furnace, that the blast is securely trapped, just as sewer-gas is prevented from escaping in an ordinary drain. This system of exterior crucibles was introduced in this country by Mr. James Douglas, Jr., at his Phœnixville Works in 1879.

The height of the furnace depends upon the character of the ore and the quality of the fuel; refractory, siliceous ore, and dense, strong coke requiring and permitting the employment of a higher furnace than the opposite conditions. With basic and easily fusible ores any height above 10 ft. (from tuyères to charging door) is rarely met with; even with refractory ores the danger of reducing metallic iron and the general unmanageability of a high furnace practically limits the height to 14 ft. Dr. E. D. Peters gives the cost of smelting an easily fusible copper-ore in a circular water-jacket furnace, 42 in. in diameter, having a capacity of 56 tons per 24 hours, as $1.98 per ton in the East, and $6.40 per ton in Arizona.

The Herreshoff Furnace is a modification of the above. It has a fire-hearth, or well, which is sometimes, for convenience of removal, placed on wheels, though more frequently it rests upon solid ground. The bottom of the furnace consists merely of a circular, concave, cast-iron plate, firmly bolted to the lower border of the water-jacket, which extends about 12 in. below the tuyères. The bottom is covered with a single course of fire-brick resting on a shallow layer of sand. The outlet of the furnace is a small circular opening in the water-jacket. There is a similar opening in the back wall of the movable hearth, which is protected by a small, separate water-jacket. Thus is formed a short, water-cooled channel from the furnace to the fire-hearth. The slag-discharge from the fore-hearth is several inches higher than this channel, so that the latter is covered several inches deep with molten material, and the blast is completely trapped. The slag runs out from the fore-hearth continuously; the matte is tapped at intervals. In the latter operation the slag-spout is plugged with a ball of plastic clay, so

that the blast is tightly confined even after the molten material has descended belo
the channel from the furnace. As it is sometimes impossible or inadvisable to cl
hole in the fore-hearth at the exact moment when the last of the matte has esca
first of the slag begins to flow, a tilting launder is arranged between the matte-s
molds, which, when held up by a chain, conducts the liquid to the regular mol
released by a catch, turns upon a horizontal pivot and conveys the slag in
direction, where it is cast in proper shape for resmelting.

According to Dr. E. D. Peters, from whose *Modern American Methods of Copp*
this description is taken, the cost of smelting in a large Herreshoff furnace is ver
number of men required per furnace is 10. With gas-house coke and repairs
low, the cost per ton of ore at the Laurel Hill Chemical Works, Long Island City
not aggregate 80 cents per ton of ore. The average charge of ore in the 48-in.
nace at those works was 56 tons per 24 hours, and of the 60-in. furnace 84 tons.
Mont., a 48-in. furnace, with 6 2-in. tuyères and $\frac{7}{8}$-lb. blast, smelted from 60 to 6
cined pyritic concentrates daily.

Elliptical cupola furnaces, provided with sectional cast-iron jackets, forming
high immediately above the tuyère level, are used for treating the slags result
fusion of the "mineral" of Lake Superior in reverberatory furnaces. In these
place of distinct tuyère-openings, a $\frac{1}{8}$-in. slot encircles the entire furnace, jus
water-bosh. Below the tuyères is a crucible 34 in. deep, nearly the full size of
closed by a drop-bottom. The water-bosh, which is 22 in. high, consists of curve
cast iron, fitted closely together. The cupola is 7 ft. 6 in. high, from tuyères
door, and has a major axis of 7 ft. and a minor axis of 4 ft. 9 in.

Reverberatory Furnaces are constructed of very varied forms and dimensions, b
ciples of all are the same. They consist of two main portions—the fireplace (eith
nary grate or a gas-producer) and the laboratory part, the fuel being separated fr
or the materials to be heated, by means of a fire-bridge, which is simply a wall o
brick, usually furnished with an air-channel to keep it cool. The flames draw over
and reverberate into the laboratory part, which is connected by means of a flu
chimney, which serves for the withdrawal of the consumed gases and the pr
draft. The reverberatory slagging-furnace used in lead-smelting is a modification
verberatory roasting-furnace (see FURNACES, ROASTING). It has two hearths, one a
than the other, the lower hearth being next the fire-bridge. The raw ore, having be
the flue end of the furnace, is gradually worked forward, being desulphurized on th
is finally pushed down to the lower hearth, where the heat is more intense, and the
or agglomerated, thus preparing it for the blast-furnaces. This practice is not purs
where, in many places it being the custom to feed the roasted ore to the blast-furn
out slagging. At Denver and Pueblo, Col., however, the tendency seems to be dis
favor of the preliminary slagging.

Reverberatory furnaces for copper-smelting are in general use in Swansea, and the
is, in fact, distinctly Welsh. In certain copper regions of the United States, also, fur
this class are exclusively used. The American reverberatories are modeled closely aft
of Wales, which have been in use for many years, the only improvements having been
size, which there is a constant tendency to increase, with the consequent gain in ca
The hearth of the copper-reverberatory is usually an elongated oval, the exterior shape
furnace being rectangular, however. In an ordinary furnace the hearth is about 15 ft
and 10 ft. wide, the capacity of a furnace of this size being about 16 tons per 24 hours
the works of the Boston & Colorado Smelting Co., at Argo, Col., Mr. Richard Pearce has introduced furnaces with hearths 24 × 14 ft., thereby increasing the capacity to over 28 tons per 24 hours.

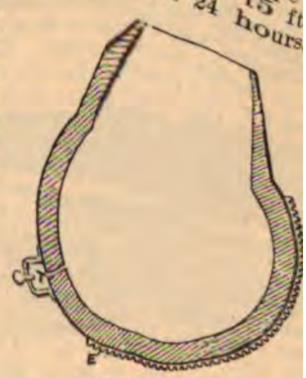


FIG. 3.—Manhés converter—section.

Within the past ten years an important improvement has been made in copper-smelting by the introduction by M. Manhés of a system of Bessemerizing copper matte, and the process is now being quite extensively used. The improved Manhés converter, such as is used at the Jerez-Lanteira smelting-works in Spain, is shown in Figs. 3 and 4, of which the former represents a transverse section of the converter, and the latter a side elevation of the converter and its carriage. The apparatus consists of an iron cylinder 4 ft. 3 in. in length, having an outer diameter of 4 ft. 2 in. It is made of iron plates $\frac{3}{4}$ in. thick. In the upper part of the cylinder there is an opening on which a conical chimney is riveted, the highest part of which has a diameter of 22 in. On one side of the cylinder, and all along its length, an air-chamber, *C*, is fixed, of rectangular shape, and in this 11 tuyères, *T T*, of $\frac{7}{8}$ in. diameter are inserted. In front of each tuyère there is a hole made in the outside of the air reservoir, which is closed by a wooden stopper. Through these holes the tuyères are kept free for the entrance of the air. At one of the ends of the air reservoir tubes, *A*, are fixed for the entrance of the *blast*, and these tubes are so arranged that, the highest being connected with the air main, *what*ever position the converter takes on turning on its axis, the supply of air is kept up un*inter*ruptedly. On the outside of the converter, and at half of its length, a toothed segment E, is placed, for the purpose of moving the converter on its axis in the manner to be describe

hereafter. On both sides of this toothed segment, and about 12 in. from the end of the converter, two flat ribs of iron are placed. Lastly, in the upper part of the converter two *strong* hooks are provided to lift it by means of a crane or differential pulley-block whenever *required*.

The carriage which supports the converter runs on rails, and each wheel has fastened to it a toothed wheel which gears into a small pinion. By means of the handles, *M*, the wheels are turned, giving to the carriage a smooth forward *or* backward movement. On the carriage there *are* four loose wheels, *R*, on which the converter *rests*, and which facilitate the movement of the converter round its axis. For the purpose of complete movement the carriage carries a shaft, in the center of which is a worm-wheel geared to the tooth segment, *E*. The shaft, when operated by the handle, *M*, places the converter in the inclined position suitable for loading, unloading, blowing, or discharging the slag as it may be required.

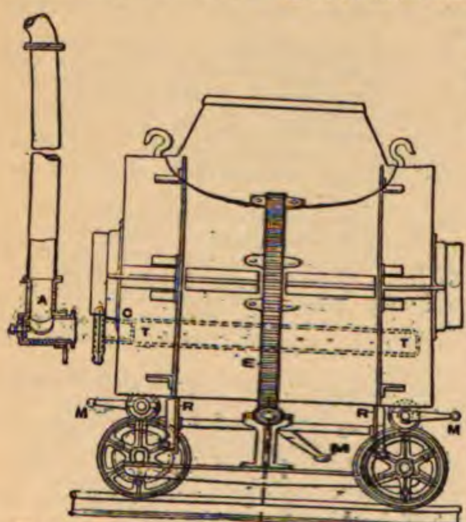


FIG. 4.—Manhès converter and carriage.

The operation of the Manhès process at Jerez-Lanteira is thus described by Señor Sanchez Massin, who is in charge of the works there: The *carriage* runs on rails placed at a level 5 ft. lower *than the* floor of the blast-furnace in which the matte is made, and on being brought in front of the same the handle, *M*, is turned, and the converter is inclined so as to allow the matte to run into it. When the charge is in the converter this is raised to a vertical position, and is carried under the chimney for the outlet of the gases and fumes, and after being thus placed the air-chamber is connected with the air-main. The air is then admitted, and the converter inclined so that the air may enter and go through the charge at a convenient depth. This depth varies with the quality and composition of the matte treated, and may also vary at different stages of the operation. The blast oxidizes the sulphur, arsenic, and antimony, and these pass to the chimney, while the non-volatile impurities are also oxidized and combine with the silica of the lining. Sometimes silica is added to the charge, by which means the lining is made to last longer. Usually a lining lasts for 24 hours, and for continual work three converters should be kept, which is easy enough, as the cost of each is only about $500. Should the slag be in excess, the blowing is stopped and the converter inclined to let out a part of it; then the converter is brought to its proper position and the blowing continued. During the operation a man is kept continually at work to clear the tuyères, and, as particles of slag and matte are expelled from the converter, the men in attendance are protected by a kind of horizontal umbrella of iron fixed on their shoulders. The end of the operation is recognized by the intense green color of the flame, which indicates that some copper is being burned. At this stage the blowing is stopped, the converter inclined, the slag raked out, and the copper run into ingot-molds.

Whatever may be the quality of the matte acted upon, success can always be attained, since this depends upon the depth at which the charge is blown. This depth can always be regulated by the inclination of the converter. The weight of the charge may vary within wide limits, but at Jerez-Lanteira it is usually one ton. The time employed in treating each charge varies from 20 to 40 minutes, according to the yield of the matte, the shortest time being for the richest matte. The heat left by one charge in the converter is enough for the next, and therefore, when the working of the converter does not keep pace with the smelting of the ores, it is better to store the excess of matte and remelt it again. The amount of coke used for smelting is 8 per cent of the weight of the matte. The slag always contains some copper, and for this reason it is usually sent back to be passed through the cupola. The fumes from the converter are made to pass through a gallery 55 m. in length, with the object of collecting some of the antimony contained in the ores.

When the Manhès system of dealing with copper mattes is compared with the usual method, a very great economy of fuel is claimed. At Jerez-Lanteira, where water-power is used for the blowing-engines, the fuel consumed is only one seventh of what would be required in the usual method. The mattes from which the best results are obtained are those containing 20 per cent iron and 25 per cent sulphur. The air is injected at a pressure of half an atmosphere, or, say, 7½ lbs. per sq. in. This process has been introduced at the works of the Parrot Silver and Copper Co., at Butte, Mont., with very good results.

Works for reference: *Modern American Methods of Copper-Smelting*, by E. D. Peters, Jr., 1891; *Copper-Smelting*, by H. M. Howe; *Copper-Smelting, its History and Processes*, by H. H. Vivian, 1881; *Elements of Metallurgy*, by J. A. Phillips, 1887; *Introduction to the Study of Metallurgy*, by W. C. Roberts-Austen, 1891; The Mines and Reduction Works of Butte, Mont., by E. D. Peters, Jr., *Mineral Resources of the United States*, 1885; Copper Refining in the United States, by T. Egleston, *Transactions American Institute Mining Engineers*, vol. ix; The Basic Process applied to Copper-Smelting, by Percy C. Gilchrist, *Journal of the Society of Chemical Industry*, January, 1891; The Bessemerizing of Copper Mattes, by T. Egleston, *School of Mines Quarterly*, May, 1885; Lead Slags, by M. W. Iles, *Mineral*

Resources of the United States, 1883 and 1884; Lead-Smelting, by O. H. Hahn, Mi
sources of the United States, 1886; The Desilverization of Lead, by H. O. Hofmann
Resources of the United States, 1887.

Fuse: see Torpedo.

Gadding: see Quarrying-Machines.

GAINING-MACHINES. Gaining is grooving at right angles to the fiber of or, more properly, to the length of the stick or plank; and it may be done by cutting both with their ends and with their sides, making a channel by reason and the timber having relative motion to each other at right angles to the stick; or by saws or cutters mounted on an axis parallel with the face of working the groove with their peripheral cutters; or by a saw having a wobbling reason of being set at an angle to an axis parallel with the face and length of

In some of the most improved gaining-machinery the reciprocating motion is at the same speed back and forth across the timber, so that cutting can be or both, as desired. In others the table has stops—sometimes as many as 12 which are set to locate the position of the gains lengthwise of the timber; and which the cutters act is determined by movable stops in the front saddle on dle is carried, so that, when the machine is once set for a particular kind of out is required for duplication. In others, again, there is a boring attachment horizontal and vertical movement, and a radial adjustment by which angular bored.

The Bentel & Margedant Gaining-Machines.—In the automatic traverse made by the Bentel & Margedant Co., for cross-gaining, square, angular, and gaining, a special point is the arrangement for feeding the cutter-head and the table, either by hand or by power feed. The machine bears a horizontal its front face, a cutter-head to the right, and a table in front. By pressing a either to the right or to the left, the cutter-head is made to move across the or short stroke, as desired, by power; or the same motion may be more slow operating a hand-wheel in front of the cutter-head mandrel. A horizontal grooving machine made by the same firm, and brought out during the spring tended for cutting a number of grooves or gains at once. There is a long hori bearing a number of heads which are adjustable in their distance apart. clamped and held securely on the table which moves across the machine heads. It has both power and hand feed. Its use is specially appropriate for cases, desks, and similar work. It takes in work up to 8 ft. 2 in. long and 24 in. wide

The Berry & Orton Gaining-Machine.—A machine which is a combination gainer and grooving machine, and a three-spindle vertical boring-machine, is made by Orton. It has a carriage or table as long as the longest timbers to be worked, mounted stands so as to be readily and rapidly moved by power or hand; and this has right traverse in front of two columns, one of which, to the left, bears the vertical boring-sp and the other, to the right, the cross-gaining head. The carriage has the same sto bolsters as are mentioned in connection with the gaining-machine; and the three spin the boring-machine have both vertical and horizontal adjustment, and are brought to work by counter-balanced levers. The object of this machine is to save handling by all the operations of gaining, grooving, and boring of a piece of timber when once in po on the table.

The Fay Groover-Head.—A very desirable addition to grooving-machines is the soli pansion groover-head, shown in Fig. 1, and which is arranged so that without removi changing the cutters they will extend to double their width. There are two disks, having a distance-washer between them, and each bearing a toothed scoring-bit on each side. There are also in each disk slots which receive the edges of gaining-bits having the minimum width which it is desired to gain with the head. For gaining this minimum width each of the gaining-bits is held by both the disks; but for increasing the width the disks are placed farther apart, so that each bit is held by only one edge, in only one disk.

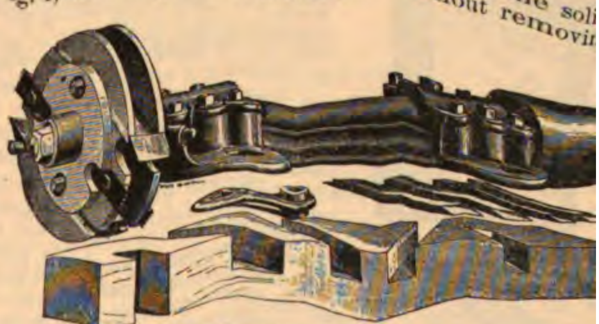


FIG. 1.—Fay Groover-head.

The Hoyt Groover-Head.—An expansion-gaining or grooving-head, made by Hoyt & consists of a hub having two radial projections, on each of which there is bolted a holder, each tool-holder bearing two tools, one of which is parallel to the radial projections the hub, and the other at a desirable angle thereto. By set-screws these tools may be se and out so as to cut to a greater or less width.

In the use of the gaining-machine it must be remembered that one head will do fo work when the width of the gains exceeds that of the cutters; although, of course, w there are many gains to be cut of a width greater than any cutter on hand, it may be be

wider cutters in order to save the time of the machine. This is a commercia
solution of which must be effected on the ground and with full knowledge of
ons; but it is well to remember that the machine lends itself to either way o
One piece of work to which the gaining-machine is specially well adapted is in th
tion of hatch-gratings, or other light work of that character, where a number of
be done at once and with accuracy, so that they will fit together in erecting.

Gap-Lathe: see Lathes, Metal-Working.

Gas-Engines: see Engines, Gas. **Gas, Fuel**: see Gas-Producers. **Gas-Fur** Furnaces, Gas. **Gas-Generator**: see Aërial Navigation. **Gas-Pressure Regul** Regulators. **Gaskets, Packing**: see Packing.

GAS-PRODUCERS. GAS-FUEL.—The increasing use of various kinds of ga both in the industrial arts and for domestic purposes, makes important a knowled different processes for producing fuel-gas, and of the heat-giving power of the seve An elaborate study of this subject is given in a paper by W. J. Taylor, read before th ican Institute of Mining Engineers, February, 1890 (*Transactions*, vol. xviii).

"The extravagant claim," says Mr. Taylor, "of some oil-gas advocates is still he by vaporizing oil with steam and then passing the mixture through a coil of hot iron oil-water-gas containing 26,600 heat-units is formed from 1 lb. of oil carrying origin 000 heat-units, while the only energy expended on the gas has been by the introduc little steam and a little extraneous heat. Theoretically, 1 lb. of oil converted into w carries 26,600 heat-units, but this is only obtainable by a large expenditure of ene amount of which is difficult to calculate; even with apparatus of theoretically per ciency, it could not be less than the quantity of heat added to the calorific energy of The cheapest artificial fuel-gas per unit of heat is common producer-gas, or "air-ga might be termed, since the oxygen for burning carbon to carbon monoxide is derived from air. The associated atmospheric nitrogen dilutes the carbon monoxide, making the weakest of all useful gases—that is, the lowest in combustible, both by weight volume. Next in the order of heat-energy comes water-gas, in which the oxygen f bining with carbon to form carbon monoxide is derived from water-vapor, and hydr liberated. For equal volumes, this gas has more than double the calorific power of Third in the ascending scale stands coal-gas, the ordinary illuminating gas distill bituminous coal, which carries more than double the heat-energy of water-gas. La highest in the list, is natural gas, which we can not duplicate in practice by any know cess. The calorific power of natural gas is about 50 per cent greater than that of c The introduction of natural gas for metallurgical purposes has largely stimulated t duction and use of artificial gas made from coal and from oil, if the vapors of the lat be fairly considered a gas."

The Loomis Gas Process.—This process was introduced in 1887, and has come i tended use in the United States and Europe, producing gas for fuel and illuminatin poses from bituminous slack coal, anthracite screenings, and other low-cost fuels. Esse a water-gas process, the producer or blast-gases of excellent quality are successfully to industrial work, making in combination with the water-gas a very economical f plant. Fuel-gas made by this process is being distributed i and towns for domestic uses, and is applied to a great variet dustrial work, such as steel-melting, melting iron, brass, silver, and other metals, tube and plate welding, smiths' for heating, hardening, tempering, and annealing furnaces, p kilns, etc. For illuminating purposes the water-gas is eith bureted or the non-luminous gas used with incandescent b such as the Welsbach. Figs. 1 and 2 show sections of the tor, which is a cylindrical iron or steel shell 7 to 10 ft. in dia and from 12 to 14 ft. in height, lined with fire-brick. *a* is door for feeding fuel and supplying air for combustion, water-gas outlet, *M* and *N* cleaning doors, *b* fire-brick arc grate, *C* passage for producer-gas to cooler. Figs. 3 and 4 sent complete plant of two generators. With fire in the tor, the exhauster *D* draws air into the top door *a* down th the bed of fuel, the resultant producer-gas being drawn up th the vertical cooling-boiler *C* to the exhauster, and by it de into the producer-gas holder. When the fuel is in a state candescence the top door *a*, is closed, and the blast stop closing the valve *B*; steam being admitted at *E* passes up th the hot carbon, the resultant water-gas passing out at the the generator through the seal *F* and scrubber *G* to the wa holder. Producer-gas can be made continuously, and enric admitting steam into the top of the generator. The quan water and producer gas varies with the kind and quality of used and the method of operating. The average make is fr 000 to 45,000 cub. ft. of water-gas, and from 100,000 to 150,0 ft. of producer-gas, from a ton of coal.

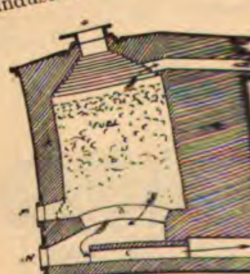


FIG. 1.

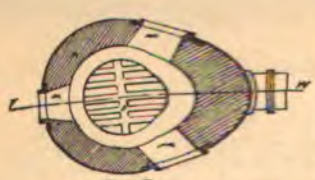


FIG. 2.

FIGS. 1, 2.—Gas-generator.

The following analyses are of gases of an average quality, and not made under exce *conditions*:

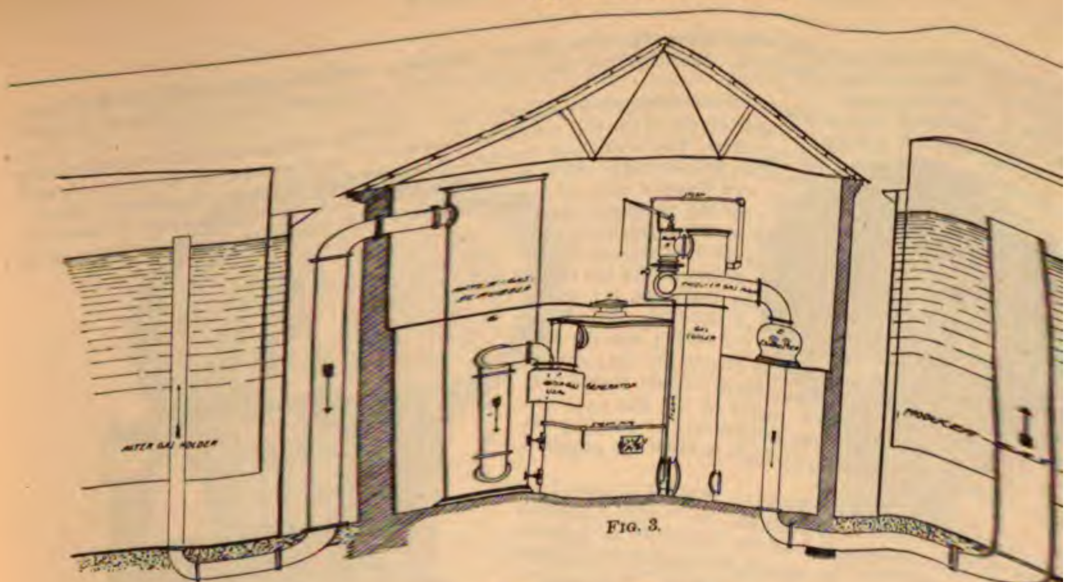


FIG. 3.

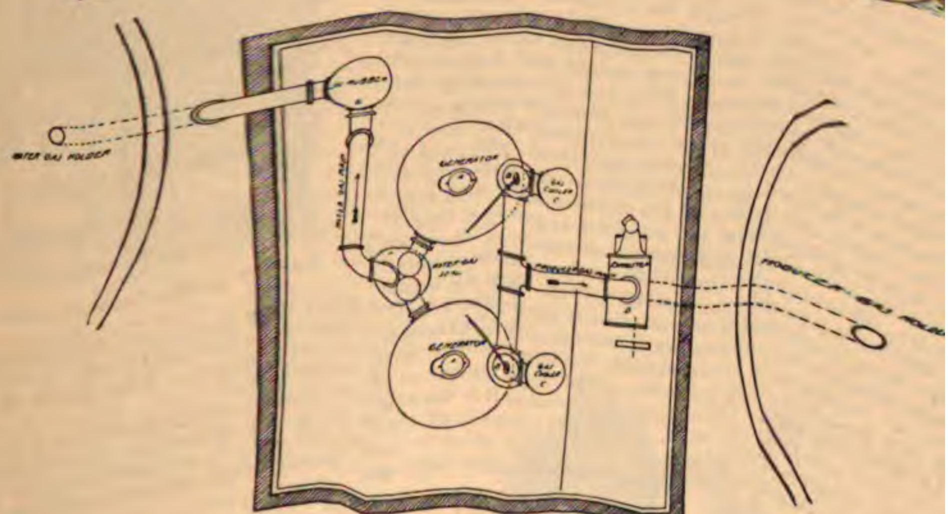


FIG. 4.

FIGS. 3, 4.—The Loomis fuel-gas process.

	Water-gas.	
CO_2	4·00	
CO	28·60	90·72 combustible.
H	55·76	
Heavy hydrocarbon	0·40	
Marsh-gas	5·96	
N	5·28	
	100·00	

	Producer-gas.	
CO_2	3·00	
CO	25·00	32·30 combustible.
H	7·30	
N	64·70	
	100·00	

The Rose Fuel-Gas Process is a combined water and oil gas method, the principal object aimed at being the thorough decomposition of the hydrocarbons by injecting them in small quantities at a number of different points, thus avoiding the cooling down of the apparatus which would grow out of the introduction of large quantities of hydrocarbons at any one point. The process will be found fully described in United States letters patent to J. M. Rose, dated October 13, 1891.

The Archer Fuel-Gas Process has recently been introduced into iron and steel works in the United States with very satisfactory results. Crude Lima oil is generally the fuel used, but other low-class oils or residuum left from crude oil after the illuminating oil has been removed are also suitable. The oil is forced by a small pump through a ½-in. pipe into the producer in which the gas is made. During its passage from the pump to the producer the oil is heated by passing through a coil of pipes forming part of the apparatus. On reaching the vaporizers the oil is brought into contact with steam, superheated in a similar manner, by which it is instantaneously decomposed, and a gas of great heating power is the result.

For heating purposes the gas is conveyed immediately as it is made through pip nace or burner, where, by the admixture of atmospheric air, perfect combustion i the process of consumption.

Taylor's Revolving Bottom Gas-Producer is shown in Fig. 5. The object of t bottom is to avoid the difficulty of getting rid of the ash and clinker common to forms of producers with stationary grates. The revolving bottom is of greater di the bottom of the combustion-chamber, and placed at such a distance therefrom t is revolved, the ash, which forms its own dome or slope at an angle of about 55°, is uniformly by its own gravitation over the periphery and into the sealed ash-pit below (which is under pressure), all without stopping the producer, or much interference with making gas. The grinding is done as fast as the ash rises too far above the central air and steam discharge, say every 6 to 24 hours, according to the rate of working. The door of the ash-pit is opened once a day for taking out the ash and clinker. The injected air and steam are introduced through a central pipe and discharged radially therefrom, in order to prevent too much travel of the gas next the walls, which is the line of least resistance, the opening being placed at a point sufficiently high to clear the required bed of ash.

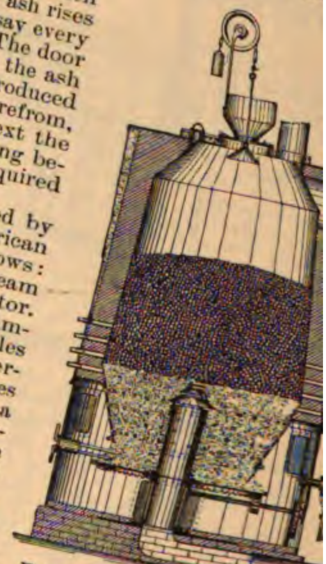


Fig. 5.—Taylor's gas-producer.

The American Oil-Gas Machine, recently invented by E. P. Reichelm and George Machlet, Jr., of the American Gas-Furnace Co., is described by the inventors as follows: "The oil is disintegrated by contact with a powerful stream of air, which enters through the bottom of the generator. The resulting spray is driven successively through a number of compartments closed by perforated disks, the holes in which are graded in fineness upward, each hole or perforation acting as a spraying tube, and this spray becomes finer and finer until the topmost disk discharges only a homogeneous mixture of air and atomized oil. The violent atomizing of the oil produces intense cold, and the moisture contained in the injected air is condensed and frozen into small bodies of ice, which return with the oil that does not pass from the generator as gas to a tank below it, where it melts and deposits as water. The desired pressure in the generator and the proportionate supply of oil are maintained by self-acting devices. The oil returning from the generator unconverted is resubjected to the spraying process until converte The returning oil only comes in contact with the fresh air injected, while fresh oil, which i fed into a separate compartment, replaces the oil converted into gas. The gas is of good quality for mechanical purposes, producing a minimum of oxidation."

GAUGE-SAW. On all sawing-machines it is desirable to have a gauge which is at once accurate and easily operated. There are numbers of them upon the market, some for square work only, others only for bevel work. One which is shown (Fig. 1) is a combination gauge, made by H. L. Beach, for both square and beveled sawing. Its essential or main feature is the

Fig. 1.—Combination gauge-saw.

use of an eccentric and lever for locking its two adjustable portions. There is a sliding piece running in a groove regulating the distance of the gauge from the saw-disk; and this, by a single motion of its lever, is loosened or tightened. The fence proper is pivoted on a horizontal axis, and may be set at any degree of bevel with the vertical, as indicated by a pointer and a graduated circumference; the same simple eccentric and lever loosening or locking it by a pinching device. There are two adjusting set-screws for keeping it in alignment with the saw. It may be readily attached to any common saw-table.

Gauge: see Measuring Instruments, Mechanical. **Gauge-Lathe**: see Lathes, Wood-Working.

GAUGES, STEAM. *Bristol's Recording Pressure-Gauge.*—This instrum
(Figs. 1 and 2) is a recent invention of Prof. W. H. Bristol, of the Stevens Instit
nology. Fig. 1 represents the instrument complete and ready for application. F
the pressure-tube with the inking-pointer attached; the front of case, dial, and co

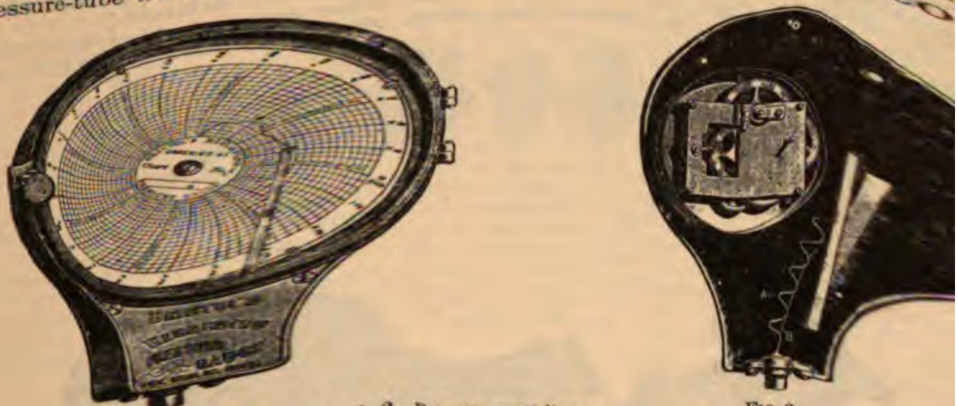


FIG. 1. FIGS. 1, 2.—Bristol's recording pressure-gauge. FIG. 2.

being removed. The pressure-tube *A* is of flattened cross-section, and bent int
mately a sinusoidal form. A flexible strip *B*, of the same metal as the tube, is sec
ends and along the bands, as shown in Fig. 2. The bent tube may be considered
of Bourdon springs placed end to end. Pressure applied to the tube produces a te
straighten each bend, or collectively to elongate the whole. This tendency to le
tube is resisted by the flexible strip *B*, and thereby converted into a multiplied later
The inking-pointer is attached directly to the end of the pressure-tube, as shown
The usual mechanism and multiplying devices are dispensed with, since the moti
tube itself is positive and of sufficient range. The special advantage of this is evid
sidering that in all other pressure-gauges the movement of the tube or diaphragm is
and requires a system of mechanism to multiply the motion many times before it is av
for indicating purposes. These multiplying devices, even under the most favorable cond
are liable at any moment to be a source of error. In the instrument illustrated the t
designed for a range of 180 lbs. per sq. in.; for other ranges its sensitiveness may be
at will, by changing its proportions, as length, shape of cross-section, or thickness.
printed charts for receiving the record make one revolution in 24 hours, and are provided with radial arcs and concentric circles, the divisions on the radial arcs corresponding to differences in pressure, while those on the concentric circles correspond to the hours of the day and night. The instrument is adapted for a vacuum as well as for a pressure-gauge, and, if sufficiently sensitive, it will serve as a barometer, and measure changes of atmospheric pressure. Another application of the pressure-tube is in the recording thermometer. The tube may be filled with a very expansible liquid, such as alcohol, and sealed. Variations in temperature produce expansion of the inclosed liquid, which in turn give deflections of the tube to correspond.

GEAR-CUTTING MACHINES. *Brown & Sharpe's Automatic Gear-Cutter*, shown in Fig. 1, is automatic in all its motions, cutting through for each tooth, and revolving the wheel until all the teeth are cut, thus enabling the operator to attend to other work. The indexing is done by a worm and worm-wheel moved by change-gears. The blank being put in place, and the cutter-head adjusted for length of stroke, the wheel is lowered by a screw having a dial reading to thousandths of an inch, until

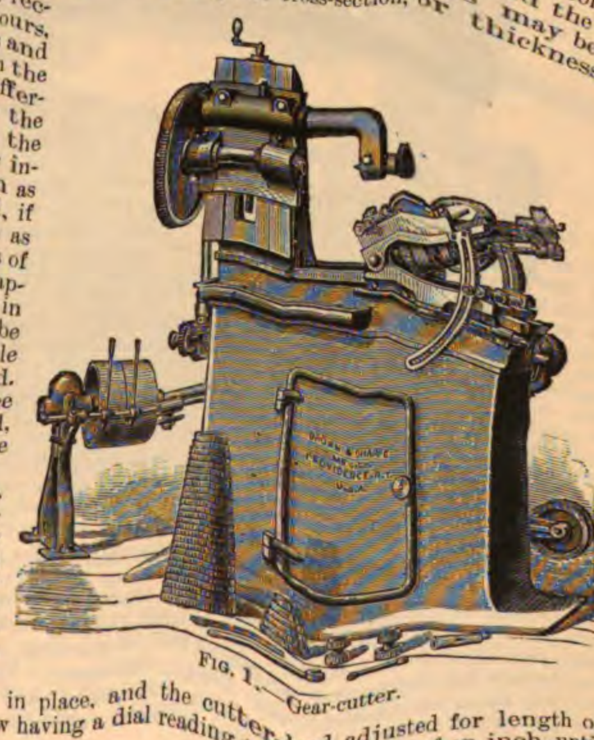


FIG. 1.—Gear-cutter.

the proper depth of cut is obtained, when the cutter passes through the blank and back by a quick return movement; the wheel is then moved the proper distance for the next tooth, and so on until finished. The cutter-head is adjustable at any angle for cutting bevel-wheels, the degrees being marked on a graduated arc, no other change being required. There is also provision for moving the cutter out of center each way, for cutting bevel-wheels.

Bilgram's Bevel-Gear Cutter is shown in Figs. 2 and 3. The principle of the machine is explained as follows: It is possible to make with any system of interchangeable gears a *rack*

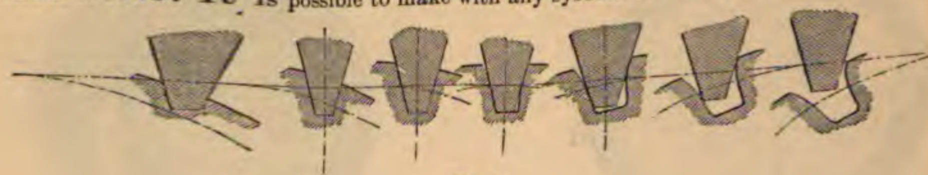


FIG. 2.

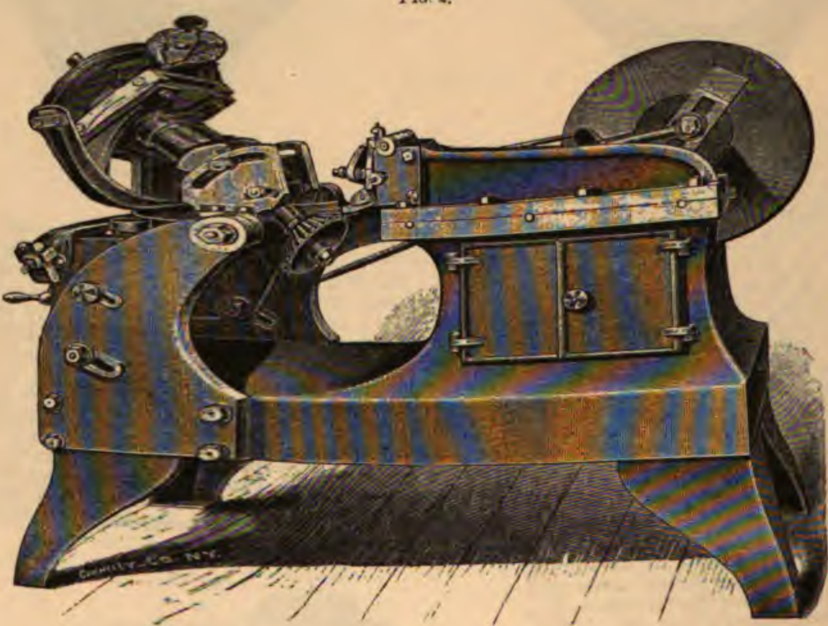


FIG. 3.

FIGS. 2, 3.—Bilgram's bevel-gear cutter.

which will correctly gear with any wheel of the set. Any wheel that gears correctly with this rack must therefore also gear correctly with any other wheel of the set; and from this it follows that if any number of wheels are made to gear correctly with this rack, they must also gear correctly with one another. If the wheels were made of some soft material, say wax, the teeth could be formed by simply rolling the blank into the rack, care being taken that the pitch-line of the blank will roll on that of the rack without slip. The desirable clearance can be obtained by giving this rack just the converse of clearance. Gears are, however, made of material that can not be removed by pressure, and the process must therefore be modified. The teeth of the rack might be made of hardened steel, with sharp edges at the ends; and by giving them a lateral motion the material could be cut away instead of being pressed to one side. The diagram (Fig. 2) shows how the tooth of an involute rack would cut its way through the rolling blank, thus forming one of the spaces between two teeth.

This is, in fact, the process by which this gear-cutter accomplishes its work. The cutting-ool represents one tooth of a rack pertaining to an interchangeable set of gears, and it obtains reciprocating motion in the manner of a shaper-tool, while the blank receives a movement s though it were rolling on its pitch surface. In bevel-gears the tool representing the rack-ooth, while cutting, passes through the varying depths or pitches; therefore the straight line r involute rack-tooth is the only available one for this purpose. The tool, instead of running rallel with the pitch line, must run parallel with the bottom of the space. This will be ore readily understood if it is considered that the rack of a bevel-gear is nothing else but a vel-gear forming a pitch angle of 180° at the apex, or a flat, circular disk, with teeth con-rging from the circumference toward the center. The tool, in cutting, should follow the tline of the teeth of this imaginary plane-wheel; and it is evident, therefore, that only one e of the converging space can be formed correctly at a time.

The machine, then, consists of two principal parts—the shaper, which holds a
the tool, and what may be called the evolver, which holds and moves the blank
that the blank shall imitate the movement of a rolling cone, the axis must, in the
be moved in the manner of a conical pendulum. To accomplish this, the bearing
which carries the blank is secured in an inclined position between two uprights
circular horizontal plate, which can be oscillated on a vertical axis passing through
of the blank. To complete the rolling action, the arbor must, in the second p
simultaneously the proper rotation, and this effect is produced in the machine
portion of a cone (corresponding with the pitch-cone of the blank) attached to th
held by two flexible steel bands stretched in opposite directions, thus preventing
from making any but a rolling motion when the arbor receives the before-descr
swinging motion. One end of each of the two bands, of course, is attached to the
the other is attached to the framework of the evolver.

Mathematically speaking, a cone does not terminate at the apex, but is exten
and thus consists of two opposite sides or surfaces meeting in the apex. Basing
ciple, the rolling cone above described is placed on the side of the apex opposite t
the blank is placed, in order to avoid an interference with the tool.

The feed mechanism effects a slow intermittent movement of the semicircular
supports the inclined arbor, thereby producing a slowly progressing rolling of the bla
reciprocating tool forces its way through the metal. The feed can be reversed or
altogether, permitting the blank to be rolled to the one or the other side by a har

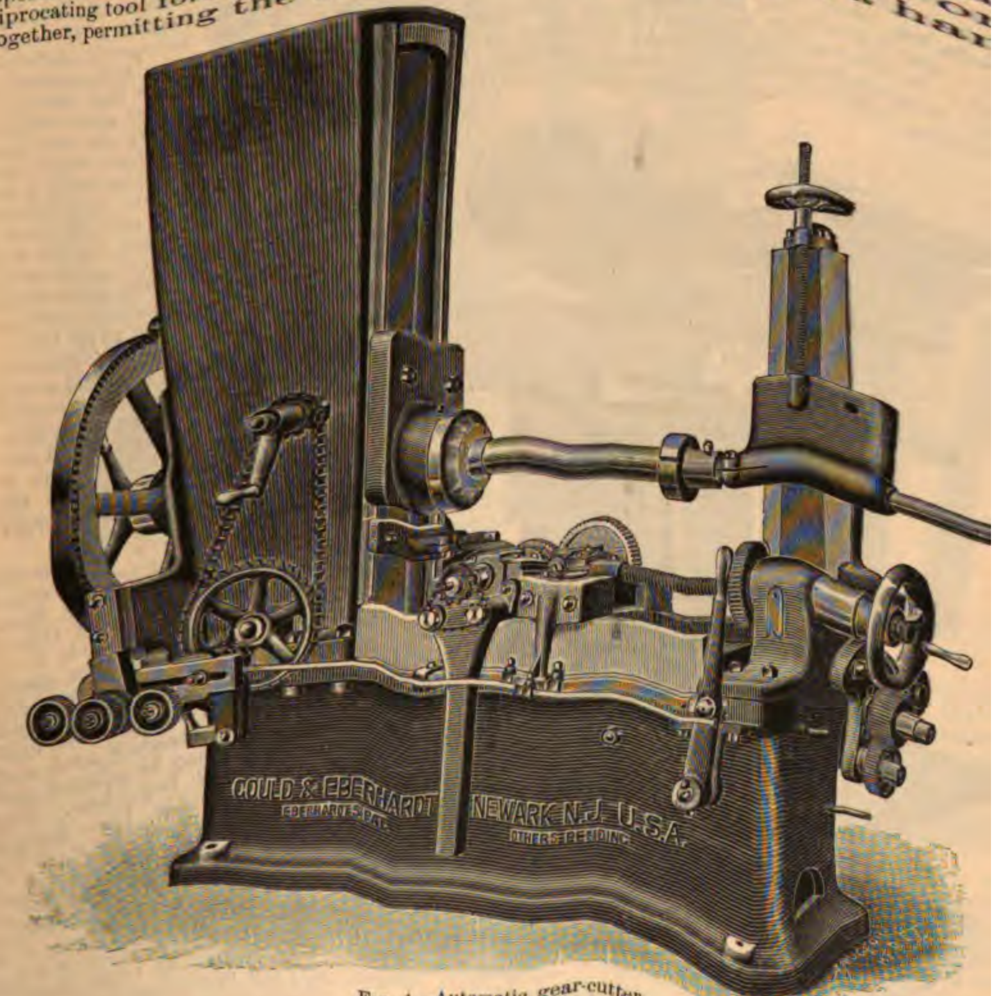


Fig. 4.—Automatic gear-cutter.

The arbor carrying the blank can be rotated independent of the rolling cone by means of
worm-wheel, worm and index plate, which enables the blank to be presented to the cutting d
vice at properly spaced divisions corresponding with the number of teeth of the desired whee
It is essential that the tool should be so adjusted that the lowest point of the cuttin
side should move exactly toward the apex of the blank, and, in order to set the tool, a gau
is provided by which the tool can be adjusted. A distance-block is used between this gau

and the tool; this mode admits of a high degree of accuracy, since variations of distances can readily be detected by the touch when the eye ceases to discern.

When a wheel is to be cut out of the solid, the tool is at first adjusted at a slight distance from its correct position, and after each cut the feed-motion of the evolver causes the blank to slowly roll, and allows the tool to cut out the stock in the manner shown in the diagram. All spaces are now treated in the same manner by using the index device, whereupon the tool is properly adjusted for one and then for the other side, each adjustment being followed by a repetition of the process in order to finish both sides of the teeth.

In securing the blank to the arbor, great care must be exercised in placing its apex exactly in the center of the evolver. A special device enables the operator to gauge the distance of the ends of the teeth from the center of the evolver, and whenever this distance agrees with that calculated from the drawing, the apex of the blank is in its right place.

The inclination of the arbor which holds the blank is made adjustable, so as to adapt it to the angle of the desired gear. This adjustment must be exactly concentric with the center of the evolver—i. e., the apex of the blank. The rolling cone is made detachable, in order that it may be replaced by such cones as correspond with the angle of the blank to be cut; but as the number of cones required would be unlimited, means have been devised to make a limited number of cones suffice.

The tool consists of a triangular bar of hardened steel, forming at the point an angle of 30°, 15° on each side, and held by a special holder. By grinding, it can be more or less truncated to suit the pitch of the gear to be cut. By this form of tool a higher degree of accuracy is attainable than with tools having curved faces made to a gauge. The proper up-and-down and sidewise adjustment is effected by two slides working at right angles, and operated by screws. The clamp which fastens the tool-holder is so constructed that it also clamps the slides to the apron, securing the necessary stability. The box in which the apron works is made in parts, and the faces are turned true with the pin-holes, in order to get these faces exactly at right angles with the pin. The latter is fast in the apron, and revolves in the two sides, in which it has taper fits that the wear may be taken up. A device for lifting the apron during the return-stroke prevents the dragging of the tool.

The tool-bar is moved by a Whitworth quick-return motion, which is attached directly to the belt-pulley. A double counter-shaft connected by cone-pulleys is employed to change the speed, if a shorter or longer stroke is desired.

Eberhardt's Automatic Gear-Cutter (Fig. 4) shows a machine for cutting spur-gears only, made by Gould & Eberhardt, Newark, N. J. It is designed to cut gears of a pitch as coarse as 3-in. and 20-in. face in steel, and is arranged so that two cutters, one blocking and one finishing, may be placed and run through together. The cutter-spindle has ample bearings on each side of the cutters. The wheels to be cut are held on the horizontal mandrel, which has a rigid outward support and bearing. The cutter is held by a spindle at right angles to the work-mandrel, on a slide which is fed automatically by the screw seen in the cut.

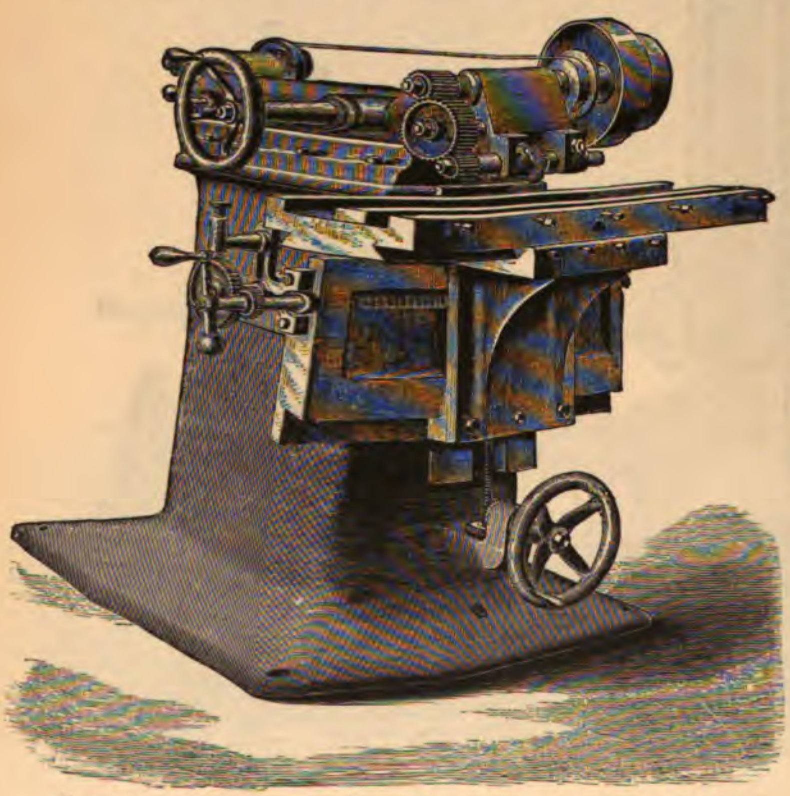


FIG. 5.—The Pratt & Whitney rack-cutting machine.

The Pratt & Whitney Rack-Cutting Machine, shown in Fig. 5, cuts the teeth of racks at any pitch, the spindle driving two cutters, which block out and finish teeth at the same time. Several racks may be cut at one time. The receiving-table has a vertical adjustment and a transverse horizontal traverse. The feed is automatic, with self-acting adjustable stop-motion. The cone is driven by a belt, and actuates the cutter-spindle through the medium of gears.

Swasey's Process for Generating and Cutting Spur-Gears.—A new process for generating and cutting the teeth of spur-wheels is thus described by Ambrose Swasey, of Warner & Swasey, Cleveland, O. (*Trans. A. S. M. E.*, vol. xii, 1891): "In the

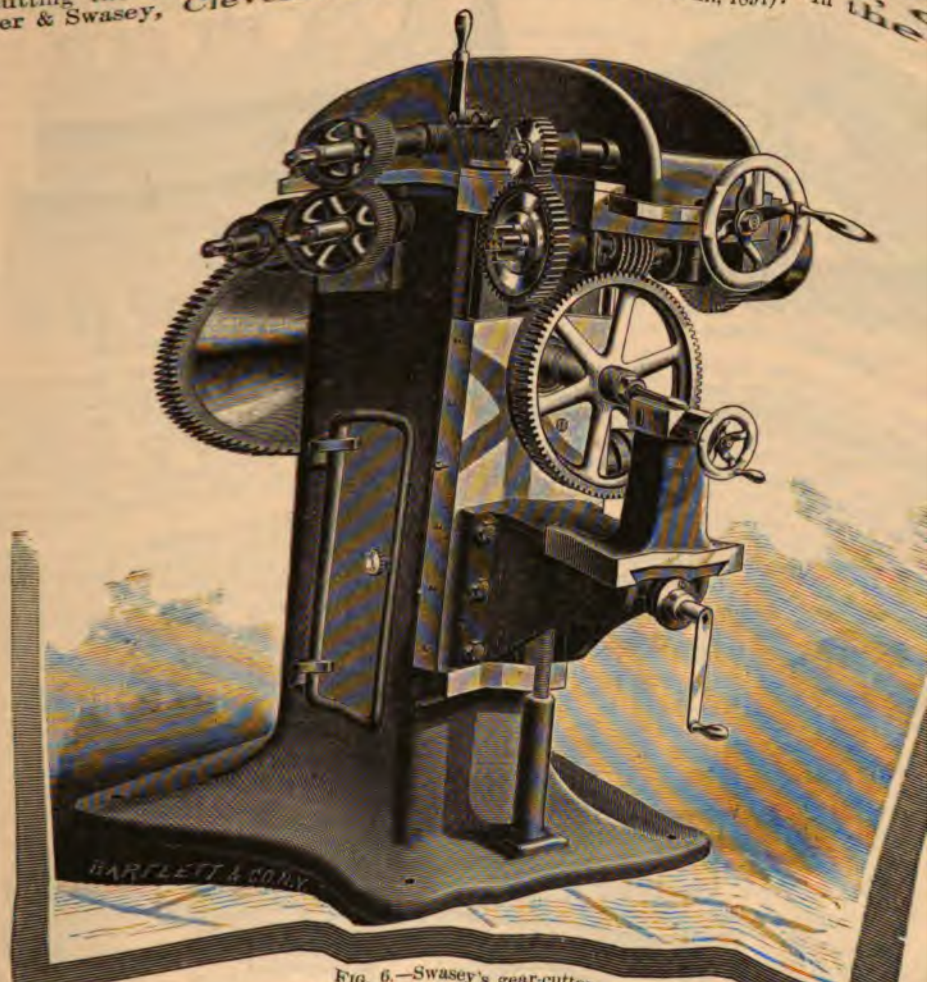


FIG. 6.—Swasey's gear-cutter

instead of making all gears so that they will run into a rack, the rack is transformed into a cutting-tool, and by it the teeth of wheels of any diameter are generated and cut at the same time. Fig. 6 illustrates a gear generating and cutting engine constructed on this principle. The cutters are shown in position as they appear in the machine when the teeth are cut part across the face of the wheel. The cutting-spindle and the main spindle which carries the wheel are connected by means of change-gears, the number of teeth to be cut in the wheel determining their proportion, on a similar principle as the change-gears of an engine-lathe, thereby causing the cutting-spindle to make as many revolutions as there are teeth required in the wheel, while the main spindle makes one revolution.

The cutting-tool is composed of a series of cutters rigidly connected, which revolve, and at the same time move longitudinally, or endwise, at right angles to the axis of the wheel to be cut; and at the same speed, it is continually revolving at the pitch-line, the motions being the same as in the case of a rack engaging with a revolving gear.

As it would be impracticable to continue moving the whole series of cutters endwise, they are bisected, and these segments are connected in series forming two sections, which revolve upon a common axis, and each section is given an independent endwise motion by means of a cam. When one section is engaged in cutting, it is carried endwise in the same direction and at the same velocity that the pitch-line of the wheel is revolving, until disengaged from it, when the cutters, while continuing to revolve, are carried back by the cam to their original position, ready for the next tooth. By means of both sections, as they continually revolve and alternately slide forward while cutting, and back when disengaged, there is a continuous cutting and generating process of the teeth in the revolving wheel. The head carrying the cutters is automatically fed across the face of the wheel, and when the cutters have proceeded once across the gear is completed.

Fig. 7 is a side elevation of a bisected cutter; and Fig. 8 shows a series of six cutters, the end one being in elevation and the others in cross-section—these having cutting portions,

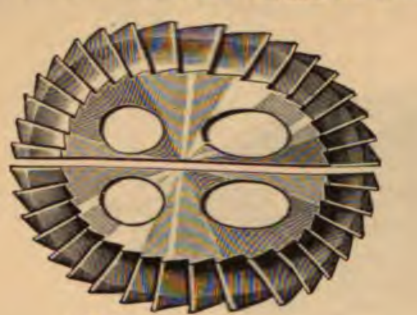


FIG. 7.—Cutter.

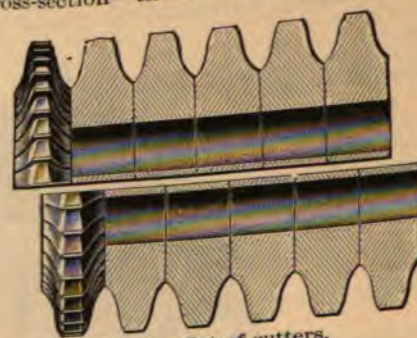


FIG. 8.—Set of cutters.

which in cross-section represent the teeth of a rack, with the addition to the diameter of a given proportion of the pitch by which the clearance and fillets at the bottom of the teeth are made. If their cutting portions are formed of cycloids, then the whole set of gear-wheels cut with them will be of the epicycloidal or double-curve system. If they are formed simply of straight sides, then a set of involute or single-curve gears will be generated and cut, or their cutting portions may be composed of both straight lines and cycloids and produce Prof. McCord's recent system of gearing, which has composite teeth with the contours partly involute and partly epicycloidal.

All the cutters in a series are made exactly alike and interchangeable, the thickness of each or the distance from the center of one to the center of that adjoining being equal to the pitch of the gear to be cut. As indicated in Fig. 7, the two segments of a cutter are first made whole, with four holes an equal distance from the center, through which the rods pass that fasten them together. After the cutters are nearly completed they are bisected with a narrow tool, leaving two holes in each segment.

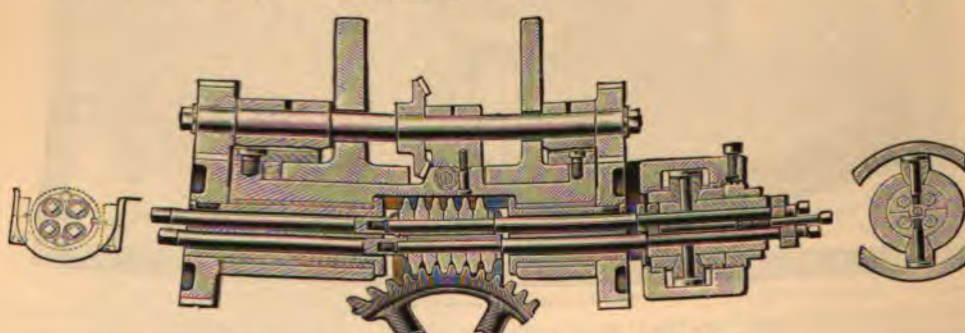


FIG. 9.—Swasey's gear-cutter—section of head.

Fig. 9 is a cross-section of the head, showing the mechanism for revolving and reciprocating the cutters. The rods which extend through the cutters serve not only to hold them firmly together but to revolve them, and at the same time act as slides for the reciprocating motion. The spindles on either side of the cutters, through which the rods extend, are revolved independently and at the same speed by means of a parallel shaft, having a pinion at each end, which engages with a large gear on each spindle. By this means the four rods carrying the two cutter sections are revolved from each end, thus avoiding the torsional strain which would result if driven from one end only. The pair of rods for each section, after passing through one of the spindles, terminates in semi-cylindrical blocks. From each of these blocks a stud extends, on which is journaled a roll, engaging with a cam attached rigidly to the head. This cam is shown in Fig. 10, the working portions being made in the form of a screw-thread, which, if extended all the way around, would have a lead equal to the thickness or pitch of the cutter. As each section of the cutters engages with the wheel but three fourths of a revolution, the thread portion of the cam which carries the cutters forward extends only three fourths of the circumference, leaving the other one fourth for the reverse curves of the cam to bring the cutters back to their starting-point. Provision is made for adjusting one section of the cut-

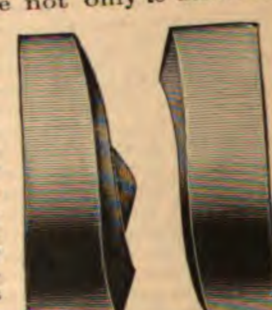


FIG. 10.—Cam.

ters so as exactly to coincide with the other. The variation in the spacing from one another is reduced to a minimum, as the series of cutters act upon both sides of teeth at the same time, and serve to average and eliminate any local inaccuracy vision of the index and driving-gears; also to obviate any tendency to crowd th one side to the other.

The endwise motion of the cutters and the revolving of the wheel at the pit exactly the same, the process of generating and cutting the teeth goes on cont uniformly around its entire periphery, so that one part is not heated more than all the teeth are cut under exactly the same conditions, and when the revolving once passed across the face all the teeth in the gear are completed and given the for each diameter of wheel; and as by the Willis theory all gears are cut to run so by this process the Sang theory is put into practice and a rack is made to cut gears.

Gear-Cutter: see Watches and Clocks.

Gears: see Carriages and Wagons.

Gin, Cotton: see Cotton-Gin.

Glassing-Machine: see Leather-Working Machinery.

GLASS-MAKING. *The Siemens Continuous Tank-Furnace.*—The use of pots in glass-making is now altogether abandoned, and the batch is introduced in, and worked from a tank occupying the entire bed of the furnace, which latter is heated by the well-known Siemens regenerative gas system. Two floating bridges or partitions divide the tank into three compartments—the melting compartment, the refining compartment, and the working-out compartment. In the illustration, Fig. 1 is a longitudinal section of the furnace, and Fig. 2 is a transverse section taken through the melting compartment looking toward the rear of the furnace.

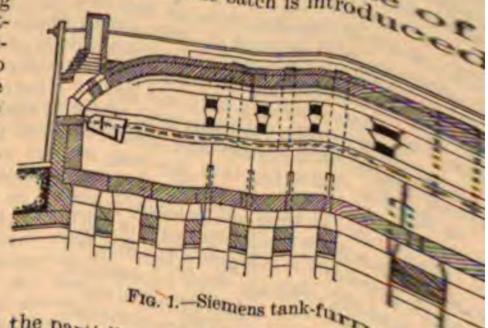


FIG. 1.—Siemens tank-furnace.

The raw material (or batch) is fed into the melting compartment through the door at the back end of the furnace, and the partially melted glass passes under the bridge into the refining compartment, where the metal, by the influence of the hi perature maintained upon its surface, is completely purified, and sinks to the flow other bridge into the working-out compartment in a thorough workable condition. ages are provided through them to maintain the sides of the tank at the requisite temperature any egress of glass, and the floating bridges are renewed as often as they come burned out. The flames play across the furnace from the gas and air ports, wh to the regenerators of the regenerative gas-furnace. In order to regulate the tempera the different parts according to the various stages of preparation of the glass in the compartments, the gas and air ports are constructed of larger or smaller dimensions, o number varied according to the amount of heat required at the different points. This facilitated by means of division walls (not shown in the illustrations), which may be buil the floating bridges to separate the compartments. The temperature of the working-out partment is further controlled by regulating the draft of the furnace chimney, by diminis which more or less flame must necessarily pass over the bridge into this compartment the refining compartment.

About the first improvement made on the Siemens continuous tank-furnace just descri was the idea of Mr. Frederick Siemens to construct the tank in the form of a horseshoe segment of a circle, with the fe ing-door and communications and from the regulator arrange on the flat side of the segmen for the purpose of cooling the ex terior surface of the tank and ren dering it available for working out holes. He also arranged a series of working-out compartments on the inner side of the curvilinear wall, each compartment communicating by means of a passage with the melting-chambers. In the continuous refining and working-out of glass it also became necessary to remove or

FIG. 2.—Siemens tank-furnace.

avoid the impurities which were found to float upon the surface of the liquid in the tank or pot, and therefore Dr. Siemens contrived a device to do that important work in a simple and inexpensive way. He constructed a fire-clay vessel or boat of oblong shape to swim in the liquid glass contained in the tank, and this boat was perforated below its draft-line so that, as it floats, the melted material flows into the boat through these holes entirely free from the im-

purities floating on the surface of the liquid in the tank or pot. To further ass of fining and working-out of the glass, the boat is made in two compartments, which is the working-compartment: the dividing partition is provided w near its bottom, so that, as the glass flows into the boat free from impurities, scribed, it becomes more fluid in the first compartment by the action of the surface than below, and consequently, in becoming denser, it sinks to the bottom compartment, whence it flows through the apertures named into the second co which is within convenient reach of the working-out hole of the furnace.

It had been observed that, in this glass-melting process, the metal as it "fines" the surface, and that, consequently, in order to work out the metal to the best the depth of the tank had to be very considerably increased, so that below the f metal there should be a layer of metal in a semi-fluid or partially sölid condition tank. One of the later glass-making patents to Frederick Siemens covered this point. He uses a deep tank, in which there are boats or floating fining-vessels made ory material, and provided with projecting horns which serve as fenders to keep t close contact with the sides of the tank.

Another improvement upon the regenerative tank-furnace for continuously mel consisted in placing the regenerators at the sides of the tank and forming an open c the tank, communicating with air-spaces on each side, for the purpose of cooling th and sides and receiving such metal as may leak through in any open accessible space

A patent was also granted in 1885 for an improvement in the art of subjecting in a glass-melting tank to the gradual application of heat, consisting of treating such in a tank so arranged and adapted that the surface of the molten metal contained shall be preserved constantly level, and having a bottom wholly or partially inclined f charging end toward the gathering end, whereby said charge, when melted, becomes o ing depth above said bottom and below the hot gases forming the source of heat. claimed for this invention that the heat can be applied more uniformly to the cha batch, and the latter becomes more thoroughly fluxed, preventing also the formation posits in the tank, or what are technically known as "cords" or "stones."

Tank-furnaces are used principally in bottle-works and in the manufacture of rolled but window-glass of a low grade has also been shown as made in one of these tank-furn In some instances they are fired by common coal from one end, the working-holes bein the other three sides. A new practice, which was introduced in France some few years by M. Clemandot, a celebrated glass manufacturer, has found much favor among glass-mak It is the coating with nickel of molds, blow-pipes, and tools used in glass-blowing. This c ing prevents the oxide of iron from being introduced into the glass from impure cullets.

Cutting Glass.—Several attempts have been made to cut glass by machinery, but up within a few years no considerable amount of success has been met with. There was a m chine in operation at the Paris Exposition which had just been brought out, and was suppose to be for cutting several tumblers at a time, although only single glasses were cut in public The tumbler was mounted upon a holder pressing upon the face of a horizontally revolving wheel, the holder being weighted sufficiently to give the proper pressure to grind out the flutes. The apparatus was automatic, raising and revolving the tumbler a sufficient distance to cut the next flute, and again lowering it against the grinding-wheel, repeating the operation until all the flutes around the tumbler are cut. There does not appear to have been any means for regulating the penetration of the grinding-wheel, pressure being simply depended upon for action.

An American glass-cutting machine, invented by Messrs. Charles & J. P. Colné, has been used for some years in the successful cutting of decanters, goblets, sugar-bowls, mustard-pots, tumblers, etc. It is not entirely automatic, but is adapted to cut all geometrical shapes and patterns, as well as a great variety of styles of cutting. The rapidity, the regularity, and the perfection of the work done with this machine insure considerable saving in the original cost price of cut articles.

Pressing or Molding Glass.—When pressing glass continuously for a long time the molds often get heated too high, and in this state glass is very apt to stick to them. This inconvenience is now done away with by a system of blowing air into the molds. By means of a revolving fan or other device, and tin pipes arranged around the furnace, a continuous stream of air is furnished. India-rubber pipes are attached to the tin pipes at suitable places. By means of these pipes, after each pressing, or as often as necessary, a stream of air is sent inside of the mold, thereby cooling it. The air circulating in the pipes may also be used for ventilation and for cooling the glass-house. Of late, attempts have been made to use presses for pressing glass by steam or compressed air. One of these presses has a set of molds carried upon a revolving bed, and is operated by a presser like a hand-press. The power, however, is applied to the presser by means of an auxiliary steam-engine, which is continually at work. Whenever an article is to be pressed, by suitable leverage the presser is forced down, then released; the bed-plate revolves far enough to bring another mold under the presser, and the operation is repeated as often as desired. Mechanism is attached and operated also by steam so as to push the pieces out of the mold after they are pressed. These are the principal features of the invention.

In the other press steam is replaced by compressed air contained in a reservoir, which may be filled by means of an air-compressing engine. The bed-plate carrying the molds has a rectilinear motion. When an article is to be pressed the mold is brought under the presser; by means of suitable valves and pipes air is sent to a cylinder-piston carrying the plunger.

The pressure of the air forces the presser down into the mold, the valves are reversed, the piston and presser fly back. A new mold is now under the plunger. The operations may be repeated as often as desired by simply opening and closing the air-valves. In the other, the pieces are forced out of the molds by rising plugs or bottoms. The different motions of this press are entirely automatic, with the exception of operating the valves. In order to form the air-bubbles which are often seen inside of solid pieces, they have been pressed with cavities on the outside, and after being reheated they are closed by pressing the outside down with suitable tools, thus inclosing the air in the cavities.

Rolling Plate-Glass.—A new method and apparatus for rolling plate and sheet glass has been introduced by Mr. James W. Bonta, of Wayne, Pa. The main features of the method are: first, rolling the glass plate on one side, then placing it between platens, then rotating both platens, then rotating the same, then lifting one of said platens, and then rolling the other side of the plate. The machine for accomplishing this work has combined a presser roller a movable platen for passing the glass underneath this roller, and a sliding frame having journals which carry the second platen. There are special devices for bringing the platens together and locking their journals, and for raising, lowering and rotating the locked platens, as well as for releasing the latter with the unrolled side of the glass uppermost, so that it may be ready for the next part of the operation.

Gold-Mill: see Mills, Gold.

GOVERNORS. We present a variety of the latest improved types of governors.

Ball's Shaft-Governor.—Mr. Frank H. Ball has recently made a new application of the dash-pot to centrifugal governors, which seems to be free from the difficulty formerly encountered with dash-pots in this connection. It is thus described in *Trans. A. S. M. E.*, vol. ix:

"The principles involved may be understood by reference to Fig. 1. The governor shown is one of the ordinary forms of shifting eccentric governors. The introduction of the spring *S* between the dash-pot and the movable part of the governor is the new feature. Its operation and effect are as follows: Suppose the long spring *D* be drawn up until its initial tension, in distance of stretch, shall correspond exactly with the distance between the center of gravity of the weight and the axis of revolution. This is what is called 'full theoretic tension.' The condition is the same as would be obtained if the weights were first placed at the center of the shaft, and the spring after attaching without any tension, the weight was then moved out to the position shown. With this relation between the position of the weight and the tension of the spring, the increase and decrease of centrifugal force caused by moving the weight to or from the axis of revolution would exactly harmonize with the changes of resistance of the spring due to said motion; and if the two forces were in equilibrium in one position, they would be so in every position at the same speed. This condition, as has already been said, should be expected to give uniform speed of the engine at every position of the governor, but has been found impracticable on account of its instability. The object of the dash-pot and spring here shown is to allow theoretically perfect adjustment of the long spring, and to furnish ample stability without making the governor sluggish, or in the least preventing a quick and delicate balancing of the forces. This spring *S* is arranged for both compression and extension, and has a range of deflection sufficient to allow the full motion of the governor, from one extreme to the other without regard to the motion of the piston of the dash-pot to which it is attached. The resistance of this spring *S*, having no initial tension, is entirely out of harmony with the other spring, and combined with them produces exactly the effect when motion takes place that is obtained ordinarily in centrifugal governors, by using springs with less than the full theoretic tension; and if the dash-pot piston should remain stationary, the same change of speed would be found between the extreme positions of the governor; but by reason of the movement of this piston, the tension on spring *S* is released, and it then ceases to be a factor in the speed, which is only the result of the long spring, and, as has been previously shown, it must be the same at every position of the weight. This theory, though somewhat obscure, seems to be correct, and its practical operation under careful tests proves it to be so."

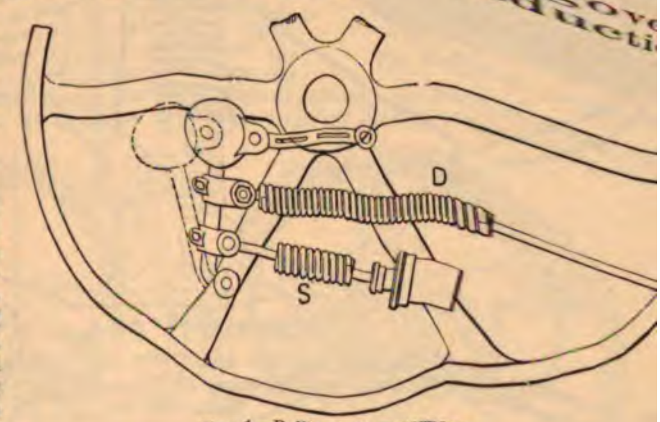
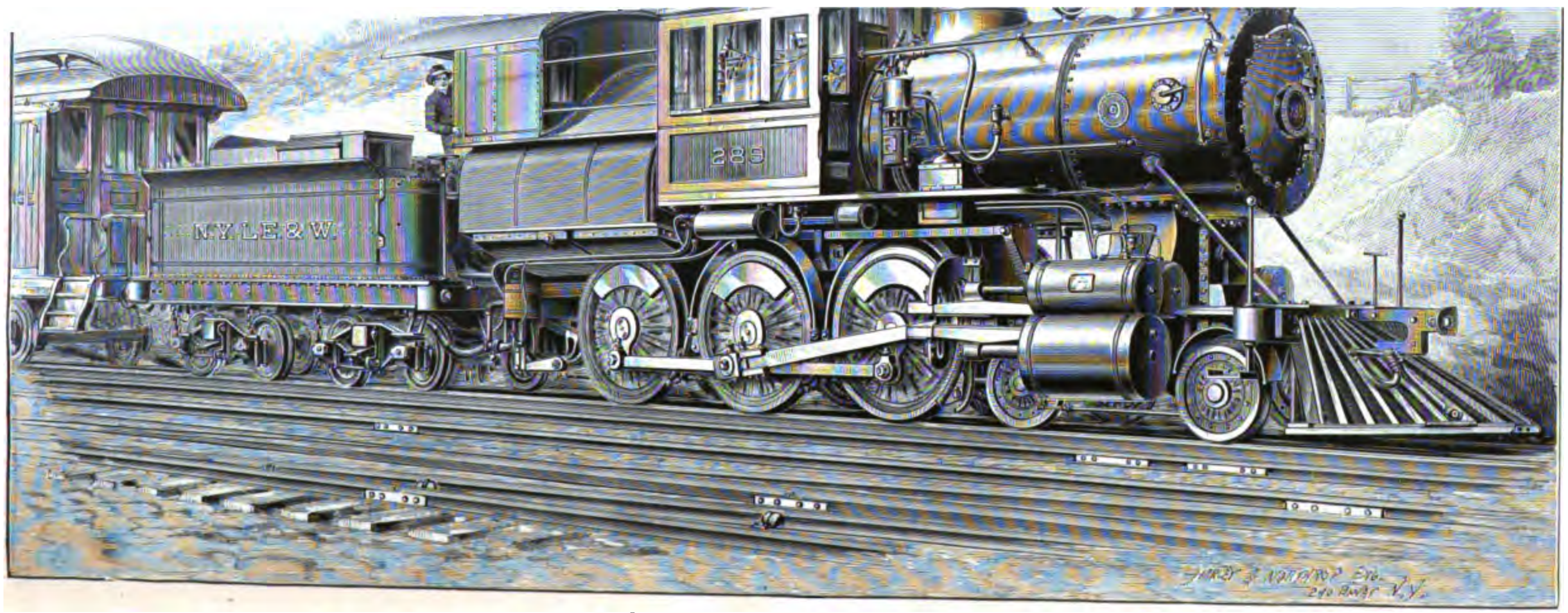


FIG. 1.—Ball's shaft-governor.

Governors are now made of various types, embodying this principle, and have been found to compel the same number of revolutions per min. of the engine under any condition of load or boiler-pressure within the full capacity of the engine.

Smith's Governor is shown in Figs. 2 and 3. It is described at length in *Trans. A. S. M. E.*, vol. xi. It was designed on the basis of the following propositions: First, a governor



COMPOUND LOCOMOTIVE.

Designation and type of locomotive.	Disposition of wheels.	Cylinder's diameter × stroke.	Driving-wheels.	Driving.	Total.	On driving-wheels, lbs.	Total lbs.	Engine and tender.	Level.	1 in 100.	1 in 50.	1 in 33.
			In.	Ft. In.	Ft. In.				Tons.	Tons.	Tons.	Tons.
1. Ordinary passenger, American type.	4-coupled wheels with 4-wheel truck	17 × 24	56 to 66	8 6	22 6	50,000	80,000	136,000	1,330	305	145	80
2. Express passenger, American type.	Ditto	20 × 24	72 to 78	7 6	21 11	75,000	116,000	188,000	2,000	470	230	135
3. Ordinary freight and mixed traffic, ten-wheel type.	6-coupled wheels with 4-wheel truck	18 × 24	56	13 6	23 7	68,000	92,000	152,000	1,825	435	220	130
4. Fast freight or heavy passenger traffic, ten-wheel type.	Ditto	21 × 26	62 to 68	12 6	23 4	101,000	133,000	205,000	2,725	655	335	200
5. Ordinary freight, Mogul type.	6-coupled wheels with leading radial pony-truck	18 × 24	50 to 56	15 0	22 6	74,000	90,000	150,000	1,995	480	245	145
6. Ordinary freight, consolidation type.	8-coupled wheels with leading radial pony-truck	20 × 24	50	14 0	21 6	104,000	118,000	184,000	2,820	685	355	220
7. Heavy freight, consolidation type.	Ditto	22 × 28	50	14 0	21 6	135,000	150,000	222,000	3,670	900	465	290
8. Heavy freight, decapod type	10-coupled wheels, with leading radial pony-truck	22 × 26	45	17 0	24 4	135,000	150,000	222,000	3,670	900	465	290
9. Light switching	4-coupled wheels, saddle-tank	15 × 24	44	7 0	7 0	60,000	60,000	....	1,580	400	215	140
10. Ordinary switching	6-coupled wheels, 8-wheel tender.	18 × 24	50	10 6	10 6	78,000	78,000	126,000	2,120	520	270	170
11. Heavy switching	Ditto	20 × 24	50	11 0	11 0	100,000	100,000	160,000	2,715	670	350	220
12. Elevated service, Forney type.	4-coupled wheels and trailing truck	12 × 16	42	5 0	16 1	32,000	47,000	....	865	215	100	60
13. Local or suburban service, double-ender type.	4-coupled wheels, pony-truck, and trailing truck	17 × 24	56 to 62	7 6	32 0	62,000	124,000	....	1,650	405	205	125

Having four pairs of driving-wheels not only is the greater part of the total weight utilized for adhesion, but the weight is so distributed as to bring a less load per axle than in either the "Mogul" or "American" types. With driving-wheels not exceeding 50 in. diameter, the length of driving-wheel base is such as to permit passing any ordinary curves, say up to 15°, or 382 ft. radius, with ease. No. 7, heavy Consolidation type, is the development of the ordinary Consolidation engine to meet the necessity for a powerful locomotive for freight and pushing service on mountain lines, inclines, etc. It is the resultant of the adoption of the same loads per axle for Consolidation engines as have been found practicable with American, Mogul, and Ten-wheel engines, the diameter and spread of driving-wheels remaining unchanged. In many locations where pushing-engines are employed, it is practicable to lay heavier rails, and, if necessary, to specially strengthen the bridges for such distance as may be required. If, however, the distributed weight of such an engine is greater than the rails or bridges can safely carry, the same aggregate weight can be divided among five pairs of driving-wheels, making an engine of the Decapod type, the dimensions of which are given by No. 8. Although a wheel-base of 17 ft. is necessary for the five pairs of driving-wheels, the passage of curves is facilitated by allowing extra play between the track and the flanges of the rear pair of coupled wheels. The rigid wheel-base is thus virtually reduced to 12 ft. 8 in., and curves of 330 ft. radius may be safely traversed. No. 9 is a light switching locomotive. It is of the simplest type possible, the fuel and water being carried on the machine itself, and all the weight, being on the driving-wheels, is utilized for adhesion. It is therefore extremely powerful for its aggregate weight. Its short wheel-base permits it to enter with ease the sharpest curves in switches and side-tracks. Such engines are built of all sizes, from 7 × 12 cylinders and 7 tons weight to 17 × 24 cylinders and 35 tons weight, and are extensively employed for handling cars at railway termini, on docks, and around furnaces, mills, mines, and other industrial establishments. For service where greater tank and fuel space is necessary than can be provided on the engine itself, a separate tender carried on four or eight wheels can be used instead of the saddle-tank. Engines for similar service are constructed with three pairs of driving-wheels, when the weight of the engine or of the rails renders it inexpedient to concentrate it on two pairs.

ed with others, is a much greater breadth of furnace and larger area of grate with th of fuel thereon, a change in the location of the cab from the rear of the engine and sides of the fire-box to a position above the furnace in some instances, and in others side of the waist of the boiler immediately in front of the fire-box, the steam-dome cated in the cab. The construction of frames, driving-wheels, cylinders, and steam-s not strikingly different from other well-known and usual types of engines. The ly increasing weight of train-loads has necessitated more powerful engines; and was not difficult to increase the cylinder capacity or piston displacement of the en- e limit of the boiler to supply adequate steam to such engines was soon reached. ge of the railroad appeared to limit the width of the boilers admissible, the frames t be spread any farther apart, and, under the practice of placing the furnace of the etween the frames, the only increase of grate-surface practicable was in the direction th. This rendered firing more difficult, and a deep bed of fuel was required to main- am-pressure; the draft of air to maintain combustion demanded greater pressure on aust, which could only be enforced by contracting the nozzle of the exhaust, ... posing a pressure upon the steam-pistons during the return strokes. This, in view large piston-surface recently coming into vogue, especially in compound locomotives, serious waste of force. The solution of this difficulty was found in an increased a of furnace-grate and fire-box to accommodate it. Space to contain such boilers interfering with the driving-wheels was procured by placing the boiler above the -wheels and frames, which were protected from ashes by a hopper-shaped ash-pit. f series of tests made by Dr. Charles M. Cresson of the Standard locomotive boiler dwin Locomotive Works, and of a Wootten boiler burning several kinds of fuel hows the claims for the capacity of the Wootten boiler as an efficient steam generator fferent varieties of fuel, including some incapable of use in ordinary locomotives, to stained, is quoted as follows by a committee of the Franklin Institute (see Jour. Inst., September, 1891):

	Total heat units in fuel used.	Heat units utilized in generating steam.	Equivalent lbs. of water evaporated from 212° F.	Per cent of total heat utilized.	
ite waste..........	11,275	7,823	8·09	69·4	Freight consolidation, Wootten.
marketable....	11,913	7,818	8·06	65·5	Passenger, Wootten boiler.
"	11,275	5,647	5·84	50	" ordinary boiler.
ous waste........	12,764	8,209	8·49	64·3	Freight consolidation, Wootten boiler.
marketable...	13,402	9,302	9·62	69·4	" " "
" ...	13,402	7,397	7·65	55·2	" " ordinary boiler.
" ...	13,363	9,138	9·45	68·3	Passenger, Wootten boiler.
" ...	13,731	7,416	7·67	54	" ordinary boiler.
20 per cent water.	7,871	3,316	3·43	42·1	Freight consolidation, Wootten boiler.

r 18 × 24 to 20 × 24 road locomotives with the Wootten boiler, a grate-surface of 76 sq. btained, the length of the grate being 9½ ft. and its width 8 ft. Between the grates and be-plate, and separated from the first by a fire-brick bridge wall, is a combustion-chamber 3 ft. long, which is set into the cylindrical part of the boiler, and correspondingly ns the tubes. By adopting so large a grate-area is obtained a low velocity of air pass- rough the fuel, and a slowness of combustion, which are of the utmost value in burning oo light to remain on the grates of ordinary locomotives, or impure fuel requiring the ustion of a large volume to produce sufficient heat. This type of boiler has been adopted any of the railways in the anthracite coal regions, which are not only carriers but pro- s of anthracite coal, and must therefore utilize the cheap grades in order to market the valuable grades, a fixed proportion of both attending the production. Separate cabs are ded for the engineer and fireman, as the former is preferably located in front of the fire- while the latter must stand on the tender.

OMPOUND LOCOMOTIVES.—During the past three years much attention has been given to oping and perfecting compound locomotives. They have been the subject of numerous ts, which may be divided into four classes, viz.:

Those with concentric cylinders, the high-pressure cylinder inclosed in the low-pressure ler, of which the most important example is the design of Mr. F. W. Johnstone, Super- lent of Motive-Power of the Mexican Central Railway, of which a number of engines een constructed by the Rhode Island Locomotive Works, of Providence, R. I.

Those with cylinders placed tandem, the high-pressure cylinder being usually in front low-pressure cylinder. Engines of this type at this time (December, 1891) appear not passed the experimental stage. An important objection is the necessary length of the orts connecting the two cylinders.

hose having two unequal cylinders, located one on each side of the engine, and ex- g from the smaller or low-pressure cylinder into a receiver exposed to the heated s of combustion in the smoke-box. The original patent covering this system was in 1873 to Mr. W. S. Hudson, late Superintendent of the Rogers Locomotive Works, son, N. J. This system has been further developed by Worsdell, Von Borries, Lindner, and Mallet, in Europe, and by Pitkin, Dean, Lythgoe, and others in the tates.

ose having four cylinders, of which one high-pressure and one low-pressure cylinder

pressure cylinder is effected by the shortest possible conduit. The valve construction is simple, and, being balanced, requires a minimum of force to work it, irrespective of the steam-pressure upon it. The distribution of force upon each side of the engine is equal. Each side of the engine is capable of working when the other is disconnected, and when so operated can produce a draft sufficient to maintain effective steam generation for running purposes—a feature of decided importance in cases of accident disabling the engine on one side. The engine always starts promptly and steams readily with the diminished exhaust-pressure, the volumes of the exhaust being greater than with the Standard or non-compound engine, and occurring twice as often in the revolution of the shaft as in either the Webb or Hudson type of engine. It is not pretended that this compound engine imparts any new properties to the steam that is used in it, so as to surpass other well-proportioned compound engines in degree of expansion, and consequent economy of steam, but that it does diminish the clearance space between the high and low pressure pistons, and promptly proceeds with the expansion in the low-pressure cylinder, while in other types of engines the exhaust from the high-pressure cylinder must be retained in a receiver to await the opening of the valve admitting it to the low-pressure cylinder."

A number of tests have been made, with much care and accuracy. The results justify the conclusions reached by the committee, and show a gratifying economy of fuel.

Dimensions of a Compound Locomotive.—An express engine built by the Baldwin Locomotive Works for the Philadelphia and Reading Railroad combines the Wootten boiler and the Vauclain four-cylinder compound system. It has a two-wheel or Bissell leading-truck, four driving-wheels 6 ft. 6 in. diameter, and a pair of small trailing-wheels under the Wootten fire-box. The leading dimensions and particulars of the engine are as follows: Cylinders, high-pressure, 13 × 24 in.; low-pressure, 22 × 24 in. Diameter of driving-wheels, 6 ft. 6 in.; of truck-wheels, 4 ft.; of boiler, 4 ft. 9¼ in. Form of boiler, straight; fire-box, Wootten patent. Size of fire-box, 114 × 96½ in. Number of tubes, 324; diameter, 1½ in.; length, 10 ft. Heating-surface, fire-box and combustion-chamber, 173·46 sq. ft.; tubes, 1,267·75 sq. ft.; total heating-surface, 1,435·21 sq. ft. Grate area, 76·00 sq. ft. Boiler-pressure, 175 lbs. per sq. in. Driving-wheel-base, 6 ft. 10 in.; rigid wheel-base, 13 ft. 10 in.; total wheel-base, 23 ft. 1 in. Weight on driving-wheels, (about) 76,000 lbs.; on leading truck, (about) 19,000 lbs.; on trailing, (about) 25,000 lbs.; total weight, (about) 120,000 lbs. Weight of tender, loaded, (about) 92,000 lbs. Diameter of tender truck-wheels, 2 ft. 9 in. Coal capacity of tender, 5½ tons. Water capacity of tender, 4,000 gal. Brake-fitting, Westinghouse automatic.

Comparative Tests of a Standard Consolidation and a Compound Consolidation Locomotive.—Tests were made in August and September, 1891, by A. Vail, General Master Mechanic of the New York and Pennsylvania Railroad, of two engines built by the Baldwin Locomotive Works, of the Consolidation pattern, duplicates of each other as far as possible, except that one was a standard engine and the other was a compound. The following is a summary of the results of all the tests, viz., two round trips of the standard engine and three round trips of the compound:

ENGINE.			Weight of train in lbs.	Average weigh on train.	Time on road.	Actual running time.	Time throttle was open.	Lbs. coal used.	Lbs. water used.	Lbs. train hauled per lb. of coal.	Lbs. water evaporated per lb. of coal.	Average steam-pressure.
					H. M.	H. M	H. M.					
Standard...	Two round trips.	South.	1,781,410	3,530,671	21 51	16 38	14 29	28,800	181,790	122·6	6·31	147·7
		North.	4,279,933									
Compound.	Three round trips.	South.	3,177,125	5,769,628	34 57	24 25	......	30,010	230,850	192·2	7·69	166
		North.	8,362,131									

Percentage of train hauled per lb. of coal, favor of compound, 36·2 per cent. Percentage of water evaporated per lb. of coal, favor of compound, 17·9 per cent.

The Webb Compound Locomotive.—Before deciding definitely on the use of compound locomotives, the Pennsylvania Railroad Co., in 1889, imported from England a locomotive made by Beyer, Peacock & Co., of Manchester, from designs and specifications of F. W. Webb, Chief Engineer and Superintendent of the London and Northwestern Railway. This locomotive was thoroughly experimented with for over a year, during which time changes were made in its running-gear, to adapt it to the requirements of an American track. The results of the experiments showed a saving of fuel over the ordinary engine of from 20 to 25 per cent. Fig. 4 represents the engine as altered. The boiler is 50 in. in diameter, straight, with copper fire-box 66 in. long, which is built with water-space below the grates and across the bottom, thereby forming an ash-pan surrounded by water. A brick arch is used in the fire-box. There are four driving-wheels 6 ft. 3 in. diameter, and a pair of leading-wheels, which take the place of the American four-wheel truck. These wheels are fitted with radial boxes, which allow the engine to curve easily, which is proved by the flanges not showing any perceptible wear. The driving-wheels are not connected by side-rods, and are equivalent to two single driver engines in one frame. The back pair is operated by two high-pressure cylinders, 14 × 24 in., which are coupled to crank-pins at an angle of 90°. The front drivers have a shaft with a crank in the center, for one cylinder. The low-pressure cylinder, 30 × 24 in., is located underneath the smoke-box, and is operated by exhaust steam from the two high-pressure cylinders when the engine is

...in., is obtained in practice from 1 lb. of petroleum refuse, while anthracite gives ...tion of only 7 to 7½ lbs., showing that the practical evaporative power of petroleum ... to 75 per cent higher than that of anthracite. Theoretically the petroleum refuse ...3 per cent greater value than anthracite, but in burning the latter 40 per cent of its ...wer is unavoidably lost, giving only 60 per cent efficiency, while in burning petro... 25 per cent is lost, giving 75 per cent efficiency. The petroleum refuse is the residue ...aphtha refuse, left after distilling from crude petroleum the kerosene, benzine, and ...products, and in Russia it amounts to from 70 to 75 per cent of the original weight ...il used. In Pennsylvania, the amount of illuminating oil obtained is from 70 to 75 ...f the crude oil used. The composition of the Russian and the Pennsylvania oils is, ...early the same.

...rquhart used a steam spray-injector for forcing the liquid fuel into the furnace. ...stion-chamber was constructed with brick-work inside it, which when heated acted ...erator. Through the brick-work were made numerous channels or gas-passages. ...-work thus offered a slight resistance to the free exit of the ignited gases, and ...hem longer in the combustion-chamber and fire-box, thus securing better admixture ...air, as well as a long circuit before they entered the tubes. The air carried in ...or, was pre-heated as hot as possible by being introduced through the forward ash-...er, and passing upward through a channel in the heated brick-work. Considerable ...was thus obtained, and also by pre-heating the petroleum. A comparison of the ...ion and cost of coal and of petroleum refuse per engine-mile in 8-wheel coupled 48-...otives on the Grazi and Tsaritsin Railway gives the following average results: ...9·08 lbs. per engine-mile; cost, 11·02 pence per engine-mile. ...eum refuse, 40·47 lbs. per engine-mile; cost, 5·84 pence per engine-mile.

...rous experiments with petroleum-fuel for locomotives have been made in the United ...th successful results, as far as the evaporative power of the fuel is concerned; but ...t of the greater relative cheapness of coal as compared with petroleum in most ...in the United States, no commercial advantage has yet been found with oil fuel suf-...justify its introduction in practice.

...otive Speed.—Mr. M. N. Forney, in a paper on this subject in *Scribner's Magazine*, ...92, discussing the prospect of a speed of 100 miles per hour being reached, concludes ..."is not much probability of attaining regular and continuous speeds of 100 miles with our present locomotives. Their fire-boxes—which perform the same functions ...achines that their stomachs do for animals—are, with the present system of con-..., necessarily contracted in size. The weight of the different parts are also limited. ...ns of the whole locomotive being fixed, the ...ly a question of steam production. Fast running," in Mr. Forney's opinion, ...other problems are of comparatively easy solution. The difficulty is to get the boiler ...tly large within the limits of size and weight to which it must be confined. It will ...o say that to be able to travel continuously at 100 miles per hour we must have either ...r fuel which will generate more steam in a given time than those we are using now ...ur engines must use less steam to do the same work; or, what is more probable still, we ...ave all three of these features combined. In the locomotive of the future, the action ...eciprocating parts will probably be more perfectly balanced than it is now; coupling-...ill either be dispensed with altogether, or their risk of breakage will be lessened ...cing the driving-wheels near together; and both this danger and the disturbing ...of the reciprocating parts will be lessened by increasing the size of the wheels. ...ble the engine—or, rather, its journals—to 'run cool,' the journals and their ...s will be increased in size so as to have ample surface to resist wear. In Mr. ...'s new engine, Greater Britain, recently built for the London and Northwestern ...y, the boiler has been materially increased in size, and he reports the remarkable per-...ce of evaporating nearly 11 lbs. of water per lb. of coal while pulling a heavy train at ...e of over 44½ miles per hour. This engine is compounded so as to use steam with the ...t economy, and is without coupling-rods. These are dispensed with by using three ...rs—two high-pressure and one low-pressure. The two former are connected to the ...air of driving-wheels, and the latter to the front pair. By this means both pairs of ...are driven by separate cylinders. A new express locomotive is now in process of con-...on in this country with a fire-box about twice as wide as those ordinarily used. The ...of improving the balancing of engines is attracting much attention, and the bearing ...s of many recent locomotives have been materially increased. Driving-wheels have ...n enlarged in size with the increase in speed."

Theodore N. Ely, in the same magazine, gives the following instances of notable train ...nts: The Pennsylvania locomotive which drew the special train of the delegates to ...rnational American Conference on their tour to the principal cities east of the ...fountains, traversed the rails of 20 distinct lines of railroad, and covered 10,000 ...ts course, without accident of any kind or unreasonable delay. Another example of ... may be mentioned—the 126,000 miles made by one locomotive between Phil-...and Washington in the year 1891—equal to five complete journeys around the ...oncerning the factor which will control the limit of speed in the passenger-trains ...re, Mr. Ely concludes as follows:

"...road-bed we shall have to demand that the alignment be almost free from curva-...he width between the tracks be increased; that the foundation shall be stable, and ...ted from rain and frost; that land-slides and other accidental obstructions shall

Of course, to obtain the speed that was sought, it was desirable to increase the diameter of the driving-wheels; but this was not done at first, nor until it was ascertained how successful had been the efforts to increase the boiler capacity of the engine. When it was found that this increase was ample, and even more successful than had been hoped for, the driving-wheels were changed, and the new ones of 6 ft. 6 in. in diameter, or 8 in. larger than the old ones, were attached. The gain in speed is most apparent, and can well be appreciated when it is remembered that the large driver makes 29·51 less revolutions in a mile than the small ones. On a trip from New York to Albany the decrease in the number of revolutions by the large 6 ft. 6 in. wheel would be 4,219·93, an equivalent of 86,154·09 ft., or a saving of nearly 16¼ miles. From New York to Buffalo the saving would be nearly $50\frac{1}{10}$ miles.

With a locomotive such as this for motive power, it is not a difficult matter to run profit-paying passenger-trains over long distances at a running rate of over a mile a minute; this, of course, assuming we have proper character of road-bed and rails, and approved appliances to insure safety and rapid speed.

LOGGER, STEAM. This name is given to a traction-machine devised by Mr. George T. Glover, which can be driven by steam over a snow road, and which, it is claimed, will draw after it from 30,000 to 40,000 ft. of logs. The machine is mounted on two sleds, midway between which the boiler is located. The boiler is of steel, 5¼ ft. in diameter, 7¼ ft. high, with 320 2-in. submerged flues, and gauged to a pressure of 150 lbs. The engine is 10 × 12 ft., and of double upright pattern. There are four wheels on the driving-axle, 4 ft. in diameter, weighing 3 tons. Each wheel is 1 ft. wide, and on its face there are 17 teeth, 9 in. apart. The angle of these teeth is 3 in.; they are held in place by bolts and nuts; therefore, if less traction-power is required, teeth of a shorter angle can be affixed. The axle of the drivers is of steel, 6 in. in diameter, 7 ft. long, and weighs half a ton. If desired, two of the wheels may be removed, and the remaining two placed on the axle in any position required. The steering-gear is simply a wheel in front, which places the tongue of the forward sled in any desired position by means of a link-belt chain running over the wheel, over pulleys attached to either side of the frame, and made fast to the sled-tongue. The drive-chain, between the engine and the drivers, is made of 1¼ in. Ulster iron, and weighs 18 lbs. to the ft. The logger is 28 ft. long, and, of course, a rigid machine of that size could not be driven over other than a level road. To overcome this difficulty, the drivers and the engine are supported by separate frames, the pivot-point of their connection being about the middle of the front sled. By unfastening the drive-chain and removing the connecting-bolts the two frames are disconnected, and the horse (the engine), as it were, may be taken from between what one might imagine to be the thills —the long timbers extending forward from the drivers. The bolts fastening the two frames together slide in slots; in the ends of the thills there are imbedded powerful springs, and to compress these springs to a proper tension are jack-screws, which are made fast to the engine-frame. It will thus be seen that the springs act as a cushion, and that the logger will adapt itself to the unevenness of a road. To further assist in this purpose there is a steam-piston, the upright box of which may be seen in the engraving over and immediately in front of the wheels. The piston-box is fastened to the frame of the wheels, and when necessary the rear sled, bearing the weight of the engine and part of the boiler, can be lifted clean from the ground by the use of the piston, thereby having but two points of contact, the front sled and the drivers, and at the same time throwing additional weight upon the latter. Increased traction of the driving-wheels is obtained by the use of exhaust-steam. The wheels are decked, and around the edges, under the frame, are heavy rubber curtains, which nearly reach to the road surface. The wheels thus work in a steam-box, are heated by steam, and when they pass over snow it is damped and compressed, and in cold weather immediately converted into solid ice. The machine weighs about 12 tons, and attains a speed of 5 miles per hour.

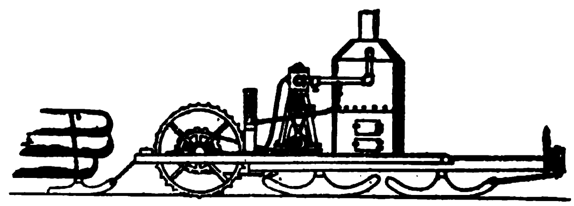


FIG. 1.—Steam logger.

Loop, Steam: see Steam-Loop.
Low Grinding: see Milling-Machines, Grain.
Machine-Gun: see Ordnance.
Magazine Rifle: see Fire-Arms.
Magnetic Separator: see Ore-Dressing Machinery.
Manganese Bronze: see Alloys.
Mankey, Woodwork: see Molding Wood-Machines.
Marine Engines: see Engines, Marine.

MEASURING INSTRUMENTS, ELECTRICAL. It needs no demonstration to show that accurate gauges for the measurement of electricity, especially when the same is used as a source of power or of light, are of as much importance as accurate steam-gauges for the measurement of steam. A gauge which will not measure the energy expended within 5 or 10 per cent, is simply blind to losses of equal magnitude in the cost of power. Up to within a comparatively few years, accurate electrical gauges did not exist outside of physical laboratories; and such instruments as were there employed were, from the very nature of their construction and the delicacy required in their handling, unfit for the comparatively rough usage

especially when the need was understood of an index which should, despite these quick changes in the current, move steadily to its reading and there stand. Alternating currents have hitherto usually been measured indirectly, as by gauging the expansion of a fine wire heated by the current. The Weston instrument consists of a fixed coil held in suitable supports, within which is arranged a movable coil, the axis of the second coil being at right angles to that of the first. The movable coil and the support for the fixed coil

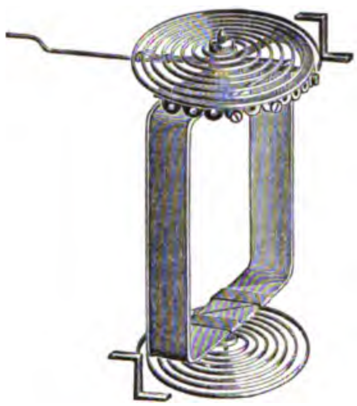


FIG. 3.

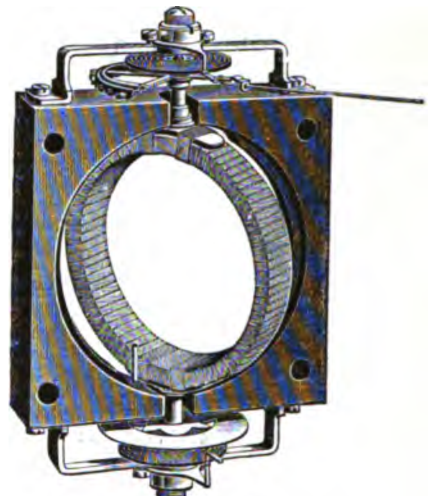


FIG. 4.

FIGS. 3, 4.—Weston electric gauge—details.

(removed) are shown in Fig. 4. The movable coil has combined with it spiral springs arranged in substantially the same way as has already been described in connection with the direct-current instrument, and its pivot carries the index-needle, which moves over a scale similar to that shown in Fig. 1. The electrical connection of the two coils is such that the current to be measured passes through both of them, and therefore the field generated around the moving coil reacts upon the field generated around the fixed coil; and as a consequence the moving coil is caused to move over a distance bearing a relation to the difference of potential between the terminals of the instrument. Of course, changes in the polarity of the current equally affect both coils. If the current reverses in one, it also reverses in the other; so that, despite these reversals, the relation of one field to the other remains the same. Therefore, the movable coil simply traverses over the proper angular distance, depending upon variation in current pressure or current strength, and thus moves steadily up to its scale-marking, and stays there. The great sensitiveness as well as the simplicity of this instrument is remarkable. By suitable changes in the electrical connections, and the introduction of resistances, the instrument may be adapted either as a voltmeter or as an ammeter.

Among the other remarkable electrical measuring instruments devised by Mr. Weston, is an ammeter capable of measuring the strength of the whole current to be used by an electric-lighting plant. Instruments of this kind have been constructed capable of measuring over 15,000 ampères. He has also devised an entirely novel series of resistance coils.

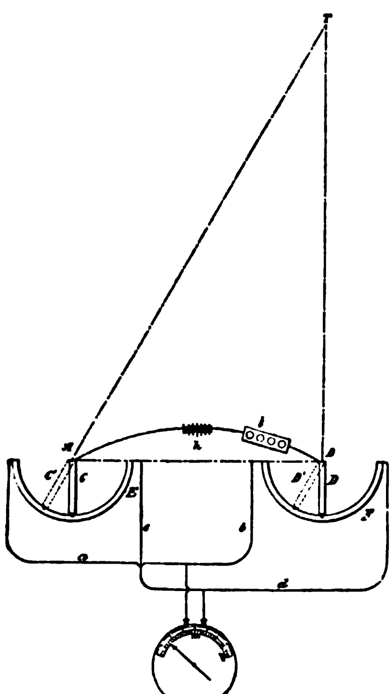


FIG. 5.—Fiske range-finder.

THE FISKE ELECTRICAL RANGE-FINDER.—This apparatus involves an entirely novel application of electricity to the measurement of distances at sea. It is the invention of Lieutenant Bradley A. Fiske, of the United States Navy, and its principle will be readily understood from the accompanying diagram (Fig. 5).

position by a locking-screw and nut, which acts like a gib. Fig. 2 is a section of the micrometer screw, nut, and fastening device.

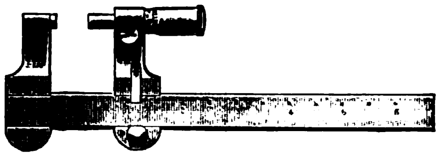


FIG. 1.—The Bellows micrometer.

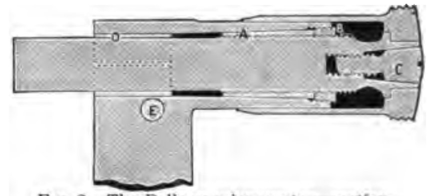


FIG. 2.—The Bellows micrometer—section.

Limit Gauges for Round Iron.—These gauges (Figs. 3 and 4) are the outgrowth of the efforts of the Master Car-Builders' Association to insure uniformity in the sizes of round

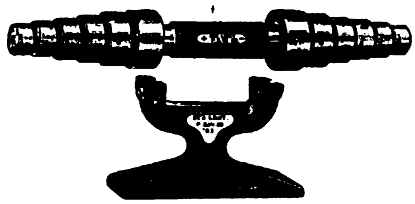


FIG. 3.—Round-iron gauge.

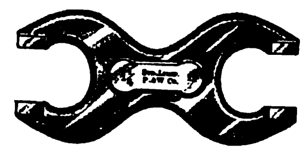


FIG. 4.—Round-iron gauge.

bar-iron for United States standard bolts. The following table of dimensions for limit gauges is recommended:

Size of iron.	Size of large end of gauge.	Size of small end of gauge.	Difference in size of large and of small diameter of iron.	Size of iron.	Size of large end of gauge.	Size of small end of gauge.	Difference in size of large and of small diameter of iron.
$\frac{1}{4}$ in.	0·2550	0·2450	0·010	$\frac{5}{8}$ in.	0·6330	0·6170	0·016
$\frac{5}{16}$ "	0·3180	0·3070	0·011	$\frac{3}{4}$ "	0·7585	0·7415	0·017
$\frac{3}{8}$ "	0·3810	0·3690	0·012	$\frac{7}{8}$ "	0·8840	0·8060	0·018
$\frac{7}{16}$ "	0·4440	0·4310	0·013	1 "	1·0095	0·9905	0·019
$\frac{1}{2}$ "	0·5070	0·4930	0·014	$1\frac{1}{8}$ "	1·1350	1·1150	0·020
$\frac{9}{16}$ "	0·5700	0·5550	0·015	$1\frac{1}{4}$ "	1·2605	1·2395	0·021

The caliper gauges are drop-forged from tool-steel, and are hardened and ground exact to size. Accompanying each set is a standard cylindrical reference gauge, hardened and ground, for each separate end

Measuring-Machines.—The Pratt & Whitney 12-in. standard measuring-machine is shown in Fig. 5. The screw is 50 threads per in., and has adjustments for compensation for wear in nut and shoulders. The index-circle is graduated to 400 divisions, giving subdivisions of $\frac{1}{20000}$ of an in.; while, by estimation, this may be further subdivided to indicate one half or even one fourth this amount. Delicacy of contact between the measuring-faces is obtained by the use of auxiliary jaws holding a small cylindrical gauge by the pressure of a light helical spring, which operates the sliding spindle, to which one of these auxiliary jaws are attached. The behavior of this "sensitive piece" readily determines the uniformity of contact of the measuring-faces at zero, and upon the gauge which is measured between them. An adjusting device for the index-line is provided, to allow for slight variations of position of the measuring-faces at zero, or for any convenient reading on the index-circle.

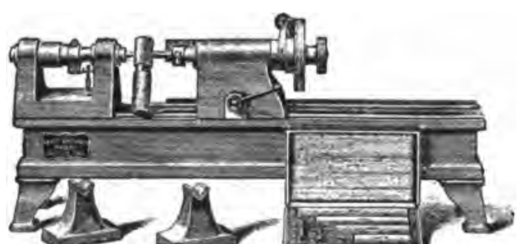


FIG. 5.—Measuring-machine.

Fig. 6 shows a measuring-machine made by the Gilkerson Machine Works, of Homer, N. Y. The screw has 16 threads to the in., and the wheel is graduated to read to $\frac{1}{10000}$ in. by decimals, and also $\frac{1}{32}$, $\frac{1}{64}$, etc. The error of the screw is corrected by means of an adjustable piece fastened to the bed of the machine. The arm shown travels with the wheel, the lower end bearing against the correcting piece being held in contact by gravity. The upper end, projecting forward, has a face on which may be graduated a vernier.

The Rogers-Bond Comparator.—From a lecture delivered at the Franklin Institute in 1884 by Mr. George M. Bond, the head of the gauge department of the Pratt & Whitney Co., who was associated with Prof. Rogers in the design and construction of the comparator, we abstract the following description: "The special features of the universal comparator are, as its name

placed as nearly as possible in the center of mass of the plate and of the stops. The magnets are intended to overcome the unequal pressure due to ordinary contact, a rack and pinion being used to move the plate. The magnets are used to lock the microscope-plate at each end of the traverse between the stops. The use made of this sliding microscope-plate and the

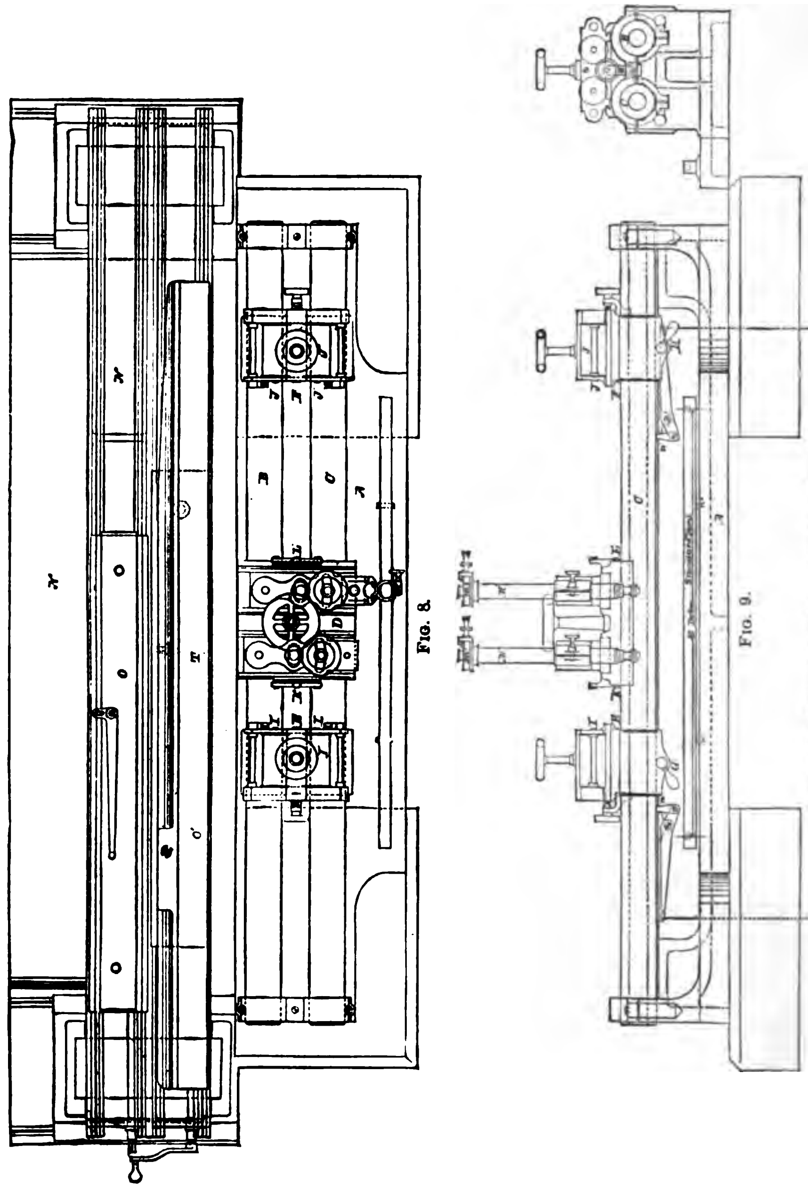


Fig. 8.

Fig. 9.

Figs. 8, 9.—Rogers-Bond comparator—details.

stops we shall see presently. Beyond the main base just described, and supported also on brick piers, is an auxiliary heavy cast-iron frame *N*, which is provided with lateral and vertical motion within the limits of zero, and of 8 and 10 in. respectively, for rough or approximate adjustment, and upon the top of this frame are two carriages, *O* and O^1, which slide from end to end, a distance of about 40 in. Upon these sliding carriages are placed tables *T* and T^1, provided with means for minute adjustment, for motion lengthwise, sidewise, and for leveling, thus permitting the adjustment of a standard yard-bar quickly, and without the necessity of its being touched with the hands after being placed upon the table until the work of comparison is completed.

"The first operation in the use of this form of comparator is to level the main base *A* (Fig. 9), then sliding the microscope-plate *D* from end to end of the steel tubular guides,

For over forty years, previous to the general change from stones to rolls, ... been in prosperous condition; and, while it stood as a prominent illustra... ...ald do, millers generally were not inclined to the idea that the system ...advantageously employed on any other than the hard wheats used in that ... and enterprise have, however, brought about the almost universal use ... reductions, and the corresponding abandonment of the time-honored ... introduction of rolls gave rise to the more scientific phase of milling. With ...owledge of the physical structure of the wheat-berry came a better under... was necessary to be done to properly separate the bran and germ from the ... portions. The system of low-grinding made the elimination of these portions ... the fine, branny particles became inseparably mixed with the flour, as did ... held in the wheat-berry. The Austro-Hungarian or high-grinding system ... separation at early stages of reduction, thus making it possible to produce ... Gradual reduction, where buhr-stones are used, is attended with the same ... grinding, though in a far less degree. The fine branny particles and some ... mixed with the flour, due to the more or less tearing action of the surface ... bran, especially with hard wheats, and subsequent treatment by reel and ... remove them. With proper treatment of the wheat by rolls the fine, branny ... crease-dirt, so objectionable when obtained in the early stages of reduction, are ... wholly avoided, the middlings obtained are clean and sharp, the bran large and ... preserving the natural sweetness of the grain. A great impetus was given ... the introduction, in 1874, of the Wegmann roller-mill, in which rolls of ... These mills were introduced into England in the fall of 1876, and into ... United States the spring of the following year, by Mr. Oscar Oexle, of Augsburg, ...ria.

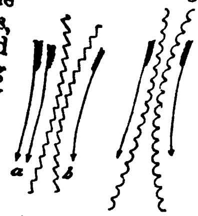
The essential features of this roller-mill that found ready acceptance with millers were: squeezing action of the rolls, the character of the roll-surface, the differential speed of the ...s, and the use of springs to keep the rolls up to their work. Soft iron, stone, chilled iron, steel rolls had previously been used, and, it was claimed, did not possess a uniform ...ous surface.

Close upon the introduction of the porcelain roll came the more extended use of corru...ed chilled-iron rolls, especially for the earlier operations upon the wheat-berry, technically ...own as break-rolls. Smooth rolls had for some time been used for flattening the germ, ...d, indeed, for crushing wheat, while the middlings were usually treated on stones. In the ...ly part of 1878 great interest was aroused in roller-milling, especially in America. The ...rk done by rolls began to be appreciated. Since 1878 there has been a gradual conversion ...m stones to rolls. This period has been marked not alone by the introduction of rolls, but the practical application of principles and appliances suggested by the processes employed the treatment of the products coming from the rolls. The period is also marked by the ...ined mechanical construction of the various appliances now used.

Rolls.—Rolls are now made almost exclusively of chilled iron, with either smooth or cor...gated surface, according to the nature of the work they have to do. The peculiar gritty ...rface of porcelain rolls renders them well suited for the reduction of purified middlings, ...t their lack of durability as compared with the chilled iron has led to a preference for the ...ter. Smooth rolls are generally delivered to the buyer with polished surface, but attain a ...lled surface after being in use a short time. They then give the best results. This is due the increased friction between the particles of material operated upon and the surface of ...rolls. It should be understood that, as this friction is increased, the pressure required for ...luction is decreased. Prof. Kick gives the coefficients of friction for polished chilled rolls hard semolina dressed over No. 7 silk as 0·213; that for fine dull surface, 0·287; and for ...ls that have been in use, 0·325. On No. 2 middlings the coefficients are given as 0·194, ...38, and 0.306 respectively. Porcelain rolls give a coefficient of 0·404 for fine semolina, and ...34 for No. 2 middlings. Prof. Kick also states that the whiteness of flour obtained with ...celain rolls is due to the greater fineness of the product and not the small proportion of ...n impurity.

The two rolls of a pair may have the same peripheral speed, or what is termed a "differ...al" speed. When run equally speeded, smooth rolls act to granulate, by crushing or ...ezing. When hard wheat is passed between smooth rolls equally speeded, and adjusted proper distance between, the berry is split lengthwise, opening out the crease and setting ...rease-dirt, and more or less loosening and releasing the germ. With soft wheat there is ... of a crushing effect. Smooth rolls are mostly used for all reductions of purified mid... reducing the large middlings, and when run equally speeded, flatten the germ without ...bbing action, which tends to tear it. When speeded differentially, they effect a com... crushing and rubbing action, and require less pressure to do their work than when ... speeded. This has led to the general use of differential speeds, and thereby power is ...oretically considered. A differential speed of 1¼ to 1 is commonly used on smooth rolls. Prof. Kick states ... smooth rolls in crushing use about double the force that is ... for the shearing action of grooved rolls in the actual work of reduction, or the crushing is twice as great as that for shearing. A further advantage of differential ... the avoidance of "caking" of the materials on the rolls. ...gated rolls are generally used for all reductions other than the sizing and reduction ...ngs and treatment of the germ, the number of grooves corresponding to the size of ...les of material operated upon. Many forms of groove have been employed, though

but two have attained extended use. They are the sharp and dull corrugations as represented in Figs. 1 and 2. The first sharp form of corrugation used had the sides of the flute equally inclined, but the form shown in Fig. 1, as introduced by Ganz & Co., of Buda-Pesth, Hungary, is the type of groove now employed for what are termed cutting-rolls, as opposed to the round rib or non-cutting rolls (Fig. 2). The action of the sharp groove is essentially that of shearing; relative speed of the grooves, however, being necessary in producing this effect. Rolls equally speeded would act to crush and bruise the grain, while to produce a shearing action a differential speed of 2 to 1 is necessary, that one groove may overtake the engaging grooves on the mate-roll. Consequently, these rolls are generally speeded 2 or 3 to 1. The relative position of the acting surfaces of the grooves is shown in Fig. 1, where *a* is the fast roll, the edge of flute pointing downward, while those of *b*, the slow roll, point upward. If *b* were made the fast roll, the action would be that of crushing and rubbing.



FIGS. 1, 2.—Corrugated rolls.

With the sharp flute four dispositions of the acting edges are permissible, as shown in Fig. 3, thus providing for different qualities and condition of the grain—as, sharp to sharp for tough wheat, and dull to dull for hard wheat; with the other arrangements for intermediate qualities.

In December, 1881, Mr. William D. Gray, of Milwaukee, Wis., took out letters-patent for a form of corrugation in which the ribs were abrupt on one side and rounded on the other, thus obtaining the cutting and non-cutting effect according to the dispositions of the acting sides of the flutes. With sharp-cut rolls the edges left by the corrugating tool are soon lost, a day or two, it is stated, being sufficient to make them feel smooth. They can be used from one and a half to two years before requiring to be recut. A twist or spiral direction along the roll is given the grooves to prevent those of one roll catching in the grooves of its mate. This also tends toward a more severe shearing action.

The direction of the twist may be the same on each roll of a pair, or disposed in opposite directions. In the former case the grooves cross at line of contact of rolls, while in the latter they are parallel at that line. On May 25, 1880, Mr. John Stevens, of Neenah, Wis., received letters-patent for a roll having a dress formed of grooves with rounded divided ridges, as shown in Fig. 2.

For this form of corrugation is claimed less cutting of the bran and breaking of the germ. The number of grooves employed for the several stages of reduction increase as the products become finer. For the five successive break rolls usually employed they may be 10, 12, 14, 16, and 20 grooves per in. of circumference of roll. The bran-rolls may have 24, and the middlings reduction-rolls 32 grooves per in. With sharp corrugations there are more grooves than with the round, and practice varies in regard to the numbers given above, some preferring finer-grooved rolls. The differential usually employed for breaks is 2¼ to 1, while the same, or 3 to 1, is used with scratch-rolls—rolls with dress formed of shallow-waved grooves, 32 per in. The diameters of rolls generally used are 9 and 6 in.; the lengths, 12 to 30 in. Nine-in. rolls are usually run at 300 to 400 revolutions per min., and the 6-in. rolls 600 revolutions, the peripheral speed being 706 to 942 ft. per min. First-break rolls run at these speeds will pass from 90 to 112 lbs. of wheat per in. of length of roll per hour. Where six breaks are employed, an increase of about 1¼ to 1½ times the grinding length of first-break roll is made, this taking place at the third or fourth and following breaks.

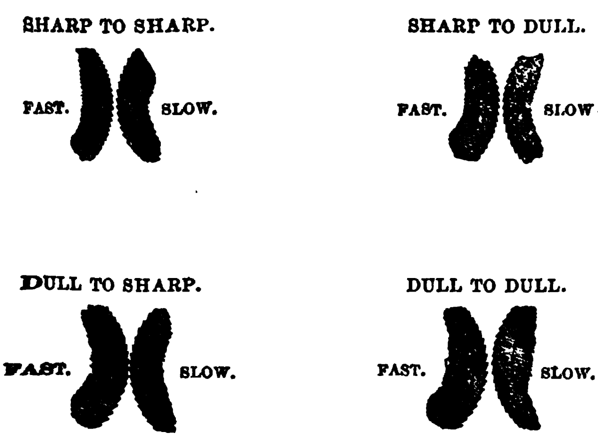


FIG. 3.—Corrugated rolls.

Variation in practice makes it difficult to state proportions of grinding surface for middling-rolls. A given size of roll grinding middlings will handle about three fourths the weight of material that the first-break roll of same size will pass. The pressure on roll-bearings is the controlling factor in the calculation for power required, the actual work of granulation being comparatively insignificant. Pressures up to 3,500 lbs. per bearing are used, the work of friction thus being for a 2-pair mill 15 horse-power. About 1,000 or 1,500 lbs. per bearing are perhaps average pressures for 9-in. rolls, having spindles 2¾ in. diameter. Six-in. rolls are used with 600 to 1,000 lbs. per bearing.

Roller-Mills.—In Fig. 4 is shown the well-known Stevens roller-mill. The frame is of the "skeleton" construction, composed of the two side-frames or legs, which are bolted to a rectangular bed or top. The rolls are mounted in boxes as shown, the two inside boxes being rigidly fastened to the bed, the two outer ones sliding on finished surfaces. A V-shaped gib,

bolted to the bed, preserves the linear motion of the sliding-box. Relative position of the rolls is attained by the adjustments, as shown in Fig. 5. At each corner of the bed of the machine are cast lugs which sustain the backward thrust of the movable rolls. Into these

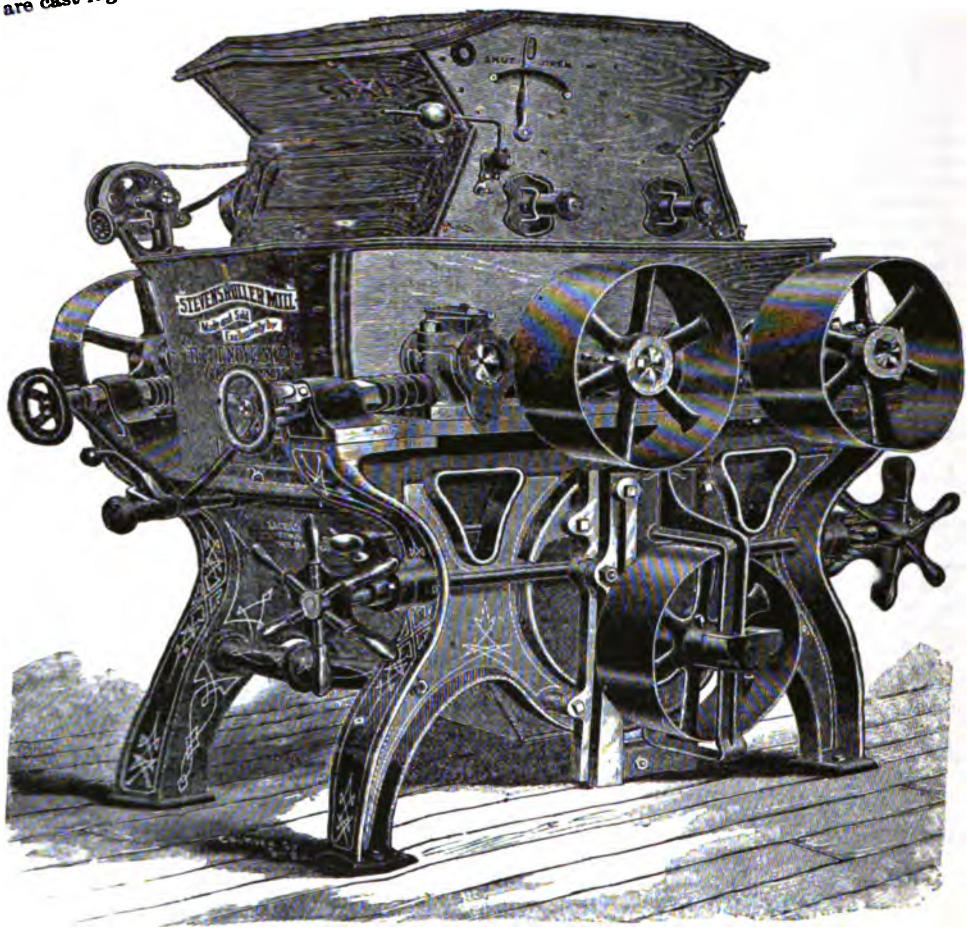


FIG. 4.—Stevens roller-mill.

lugs are fitted threaded sleeves, through which the hand-wheel stem is passed. A hexagon head on the outer end of this sleeve provides for turning it, and it is screwed firmly into the lug, so as to act as a stud for the spring-nut shown to work upon. The hand-wheel stem is threaded at its inner end, and passing through a hexagon nut seated in the sliding-box, abuts against the fixed box as shown. Turning the hand-wheel moves the sliding-box away from or toward the fixed box, and the proper grinding tension or pressure is secured by setting up the spring-nut. Vertical adjustment of the fixed roll is secured by the parts as shown in Fig. 6. The adjusting screw and dowel in which the box rests raise or lower it, while the binding screws secure the box firmly to the brackets after the necessary adjustment has been made. The dowel aids to preserve the fixed lateral position of the roll-bearing. The boxes project beyond the end of the short roll-necks and have enlarged recesses to retain the oil and prevent its running down into the frame. The tightened pulley, mounted in its spindle, runs in a frame vertically adjustable by means of a rack and pinion operated by the cross-shaft shown, which latter is held from rotating by pawl and ratchet-wheel, and is readily turned when desired from either end of the machine. The pulleys shown drive the first rolls of each pair, their mates being driven either by belts or gears, arranged to provide the differential of roll-speed, the latter varying generally between 3 to 1 and 1 to 1. The spreading device shown at the front of the machine provides for the simultaneous movement of the ends of the movable roll without disturbing the working adjustment as made by the hand-wheels at each end of the roll. Projecting from the bed is a threaded stud, on which turns the curved arm shown, the hub of this arm being threaded to fit the thread on the stud. In front of this arm is a dog with hub threaded the same as the arm, and having its outer end bent so as to *form a stop* for the curved arm to rest against. At the outer end of the stud is a small hand-wheel hav-

ing a left-hand thread. Extending from the stud to each hand-wheel are levers, one end of each pressing against the hub of the curved arm, the other ends bearing against the inner end of the hand-wheel hubs. Near the hand-wheel stem and attached to the threaded sleeve through which it passes, is placed a fulcrum, the latter being thus between extremities of the levers—the operation of the whole being such that by rotating the curved arm, say from left to right, it advances along the stud, pushing the inner lever-ends toward the frame, and forcing the hand-wheels in the opposite direction, and therefore the roll away from its mate.

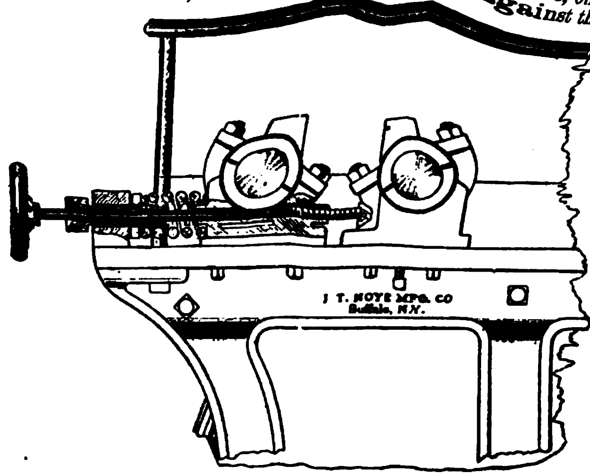


FIG. 5.—Roller adjustment.

By advancing the dog along the stud and setting up the small hand-wheel tight against it, any desired position of the curved arm can be maintained. Rotating the curved arm, the dog remaining fixed, alters the adjustment of the rolls, but they can be restored to their previous adjustment by bringing the curved arm back to the dog. Generally about ⅛-in. is the maximum spread of rolls required. The wooden housing is parted horizontally at the roll centers, the top being lifted bodily so that the rolls can be easily removed when necessary. In the top is placed the feed-device. This consists essentially of two gates, extending across the top part of the housing, and swung on axes at their upper edge, and connected by levers and links, so that motion of one implies that of the other. The upper gate forms one side of a V-shaped hopper, into which the material falls. The lower edge of the other gate approaches a feed-roll located as shown by the extended bearings near the bottom of feed-hoppering. Fastened to the shaft on which this gate swings is the arm carrying the counterweight.

When no material is in the hopper, this lower gate is swung against the feed-roll, but as material enters in the upper gate it accumulates in the hopper formed by this gate and the stationary cant-board at center of the housing, until the weight is sufficient to overcome the effect of the counter-weight, when this upper gate swings down, allowing the material to pass to the space below it, where it meets the lower swinging gate, and passes between its lower edge and the feed-roll to the grinding-rolls beneath. The secondary hopper is provided so that material coming into it from the first hopper will have a chance to distribute itself over the entire length of the feed-roll. The greater the quantity of material pressing against the upper gate, the greater the opening at the feed-roll, and consequently the greater the quantity passing to the grinding-rolls. The desired quantity of feed can be obtained by adjusting the counter-weight on its arm. The lower part of the housing contains the brushes for cleaning the rolls, and the door in front permits access to materials passing from the rolls. The feed-rolls are driven by a single belt passing from the neck of one slow roll over each pulley on the feed-rolls, and the tightener-pulley shown at top of the housing.

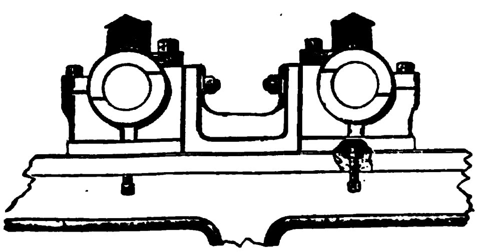
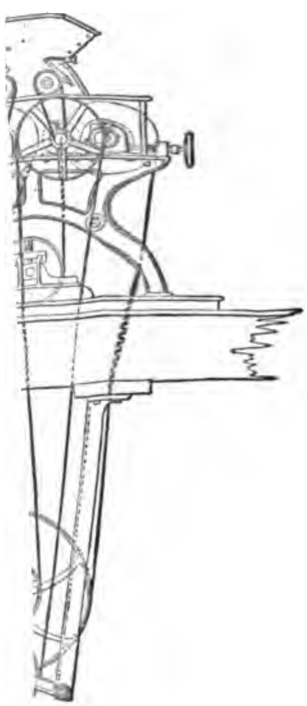


FIG. 6.—Roller bearings.

The following table gives the dimensions, capacity, etc., of mills using a belt-drive on the slow roll:

	9 × 30.	9 × 24.	9 × 18.	9 × 15.	6 × 20.	6 × 15.	6 × 12.
Length } Space over all	5'-2"	5'-2"	5'-2"	5'-2"	4'-6½"	4'-6½"	4'-6½"
Width } Space over all	5'-7½"	5'-0¾"	4'-5¾"	4'-0¾"	4'-3¾"	3'-7½"	3'-4½"
Height } Space over all	5'-6"	5'-6"	5'-6"	5'-6"	5'-0"	5'-0"	5'-0"
Length } Space on floor	4'-5"	4'-5"	4'-5"	4'-5"	3'-8"	3'-8"	3'-8"
Width } Space on floor	3'-5½"	2'-11½"	2'-2½"	2'-0½"	2'-7"	2'-2½"	1'-10"
Pulleys, fast rolls	18" × 7"	18" × 6½"	16" × 6"	15" × 6"	10" × 5½"	10" × 5"	10" × 5"
" slow rolls	18" × 6"	18" × 5½"	16" × 5"	15" × 5"	10" × 4½"	10" × 4"	10" × 4"
Floor to center of pulleys	3'-2"	3'-2"	3'-2"	3'-2"	2'-11½"	2'-11½"	2'-11½"
Speed	400	400	400	400	600	600	600
Capacity, bbls. per 24 hours	500 to 600	400 to 500	250 to 300	200 to 250	200 to 300	150 to 200	120 to 150
Power required (h.-p.), approximate	4 to 6	3 to 5	2 to 4	2 to 3	1½ to 2½	1 to 2	1 to 1½

ills are made with box-frame construction, and with rolls mounted y mill is the pioneer in this form of construction. In this mill ne rolls is obtained by an eccentric bush fitting over the stud, on which the swinging arms are suspended. Motion to the rolls is obtained by the use of one belt, a counter-shaft and pulleys running in boxes hung to the frame acting to transmit motion from the main belt to the slow rolls, a pulley on one end of the counter being the tightener pulley for the main belt, while the pulley on the other end of the counter serves to carry the slow-roll belt



iving-gear.

Fig. 7 shows a method for driving both fast and slow rolls in a Stevens double mill which has proved satisfactory. The large pulley on the line-shaft beneath the floor drives the fast rolls, the small pulley the slow ones. The means for tightening the belts are readily seen. In some short systems of milling only two or three breaks are made, and in such cases the machines shown in Fig. 8 can be used especially where economy of room is necessary. The machine shown has two pairs of corrugated rolls and two reciprocating sieves. The grain passes through the first or upper pair of rolls and on to the first or upper sieve. A separation of the product is here made, flour and middlings passing through the sieve and away from the machine; the large unreduced portion passes over the tail of the sieve on to the second pair of rolls, and from there on to the second sieve, when a second separation is made. The sieves have traveling brushes beneath them, thereby enabling the meshes to be kept clean. The machine is driven by a sin-

mills of 75 to 150 bbls. capacity, the power required being from $3\frac{1}{2}$ n. rolls to 6 horse-power with 9 × 30 in. rolls.

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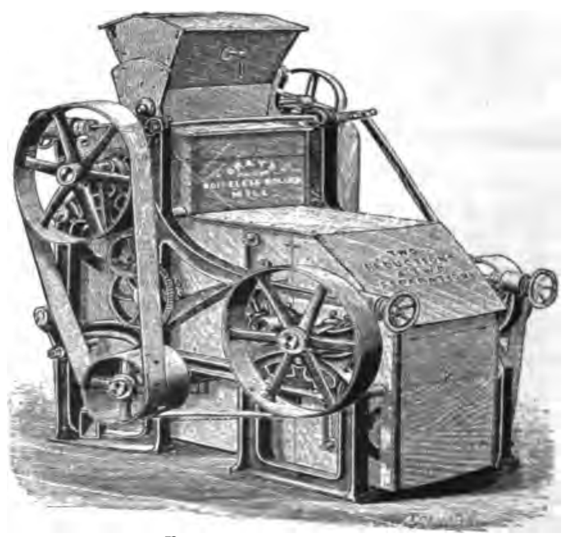

FIG. 8.—Gray roller-mill.

ound in form. In the former the tail end is larger than the head; depressed at the tail end to carry the material through. The reel-wooden ribs are attached to iron spiders on the shaft. The wooden

head is provided with the usual opening, through which is introduced a feed-spout with the customary conveyor-spiral to feed the material into the reel. The round reels, in scalping as in flour-dressing, are receiving much attention as to detail, and are gaining in popular favor. Scalping-reels are clothed with wire cloth, silk cloth, or perforated steel, and are from 18 to 36 in. diameter and from 4 to 9 ft. long. They are now commonly driven by belt or chain direct from the line or counter shaft, and are run about 28 revolutions per min. for a 32-in. reel. The slant is from $\frac{1}{4}$ to $\frac{3}{8}$ in. per foot. The reel-chests are usually made to conform to the style and sizes of those of the centrifugal and round reels for flour-dressing described later. The speed should be about 50 revolutions per min. for 18-in. reels to 28 revolutions for a 32-in. reel.

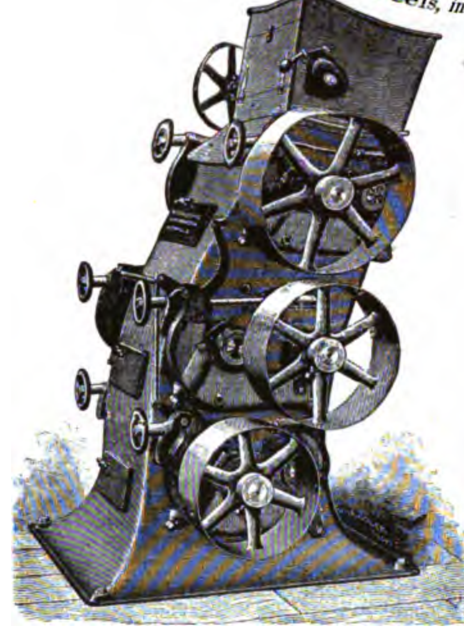

FIG. 9.—Roller-mill for corn.

Centrifugal Reels.—In recently erected flour-mills the old hexagon bolting-reel has been supplanted by the centrifugal and round reels, and especially has the latter been favorably received. The hexagon reel and its chest, the former 32 in. in diameter and from 12 to 16 ft. long, the latter exceeding these dimensions, have been found too cumbersome for modern purposes, especially in America, and reels considerably smaller and of far greater capacity are now found taking their places. Fig. 10 is a perspective view, and Fig. 11 a cross-section of a centrifugal reel, as made by the E. P. Allis Co., of Milwaukee, Wis. Referring to the cross-section, it will be seen that on the beater-shaft are placed the spiders to which are attached the beaters, the latter running lengthwise of the reel and inclined to a radius from the center of shaft, acting thus to throw the material against the bolting cloth, which, mounted on a reel-frame, surrounds the beaters, etc. The latter are set close to the cloth to keep the stock thoroughly in motion, preventing accumulation and thereby giving full action to the reel. They run spirally lengthwise of the reel, thus carrying the material gradually toward the tail end,

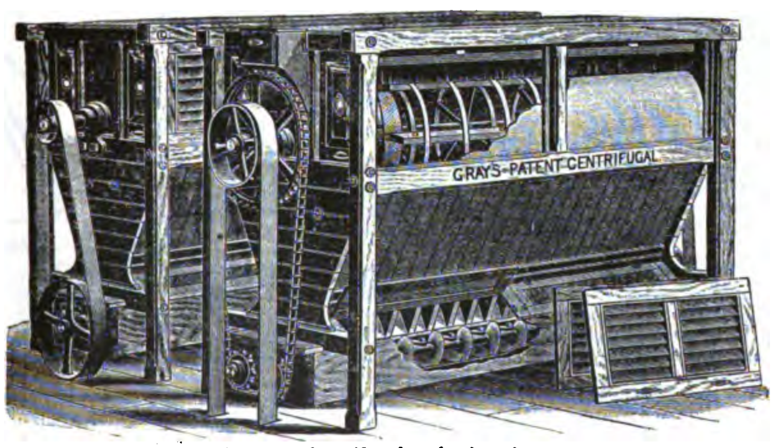

FIG. 10.—Centrifugal reel—elevation.

retaining it long enough on the cloth to do the work properly. The silk reel is mounted on trunnions which surround the beater-shaft at the head and tail of the reel, and rotates at a less speed and in the same direction as the beater-shaft. A revolving brush, as shown, is used to keep the cloth clean. The silk reels are made 21, 27, and 32 in. diameter and from 4 to 8 ft. long. The outside dimensions for a 32-in. reel-chest are: 11 ft. 7 in. long, 3 ft. 6 in. wide, and 5 ft. 3 in. high. The conveyers are placed side by side with partition between, as shown, to which the cut-off tongues are hinged, the latter extending up to the hoppering. Material is directed into either conveyer by placing the tongues against either side of the hopper. With the centrifugal it is necessary to provide some safeguard to prevent foreign substances from entering the reel. This should be a basket of wire-cloth or other suitable material which

class of machines the speed of silk reel should not be so great it the cloth by the centrifugal force due the speed. The speed of beater-shaft is usually 10 or 12 times that of the silk reel, a usual speed for the latter being 18 to 20 revolutions per min. It is the aim of makers of centrifugals at the present time to direct the material against the silk at a very acute angle, so that sliding of the material over the surface of the cloth shall take place, fully recognizing the value of this action as obtained with the now old style hexagon reel.

Round Reels.—A later machine, and one, it is claimed, that overcomes the alleged defects of the centrifugal, is shown in cross-section at Fig. 12. This class of machine has rapidly gained in favor since its introduction, about four years ago, and is said to have fully demonstrated the superiority of the round-reel bolting system. The cut shows a flour-dresser made by the Allis Co., the perspective view of which is almost identical with that of the centrifugal already noticed. The reel, mounted on the main shaft, consists of a substantial casting at each end, upon which wooden rings are placed, to which the cloth is attached. Round rods connect the head and tail end castings, and to these are attached rib-rings for the cloth and carriers, preventing contact of cloth with the rods. Within these rods is placed a light sheet-iron drum, fastened firmly to the shaft. The carriers are pitched spirally toward the tail, leading the stock continually in that direction. Sufficient space is left between the outer edge of the carriers and the cloth, also between the inner edge of the
ıable the stock to bolt properly without heating or rough hand-
; of the stock. The flouring of the material, as alleged to take
el, as also the increased quantity of bolting-cloth necessary, are
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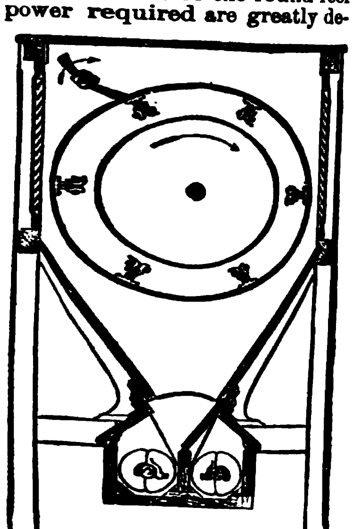

FIG. 12.
Round reel—cross section.

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upward current of air through
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rom head to tail; an inclosed air-
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n with each other, and each opening into the chamber of an ex-
table valve, arranged to regulate the strength of the air-current
separately; a series of dust-settling chambers or testing pockets,
the compartments above mentioned, and a brushing device oper-
king against the under side of the sieve clothing. This com-
fficient one. There are numerous other makes of purifiers, but
regarded as a standard machine. The use of dust-collectors in
nes has led to economy of space and increase in convenience in
air coming from the purifier-sieve.
is favorably known, and has long since settled the knotty dust-

the "cyclone" dust-collector, has recently been put into practical
ıres of which are embodied in the machine noted below.

This machine, which bids fair to be a formidable rival to the dust-collector, was lately devised by Mr. N. W. Holt, of Mancheste Knickerbocker Co., of Jackson, Mich. Fig. 13 shows the exterior, a terior. The stock is fed into the feed-spout A upon each side of t

Fig. 13.

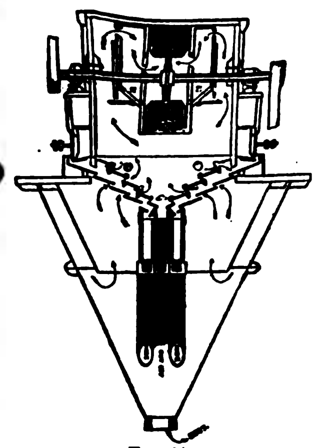


Fig. 14.

Figs. 13-15.—Holt dust-collector.

of stock may be handled at the same time. From the feed-spout it p which vibrates with the sieve or shaker, causing the stock to flow ove shelves in a thin, even sheet, where it is acted upon by the air-current, middlings then pass out at spouts C C, the cut-off at D, and the dus placed at the top provides the air-circulation. The upper series of she adjustable to suit the intensity of the air-current required at the sev while gates at the eye of the fan control the air-circulation as a whole. discharged from the fan through the pipe leading downward from the into what is called the cyclone part of the machine, where the dust an eventually settling at the bottom of the cone-shaped part and passing a the air returning through the sieve, to be again used. The same air and, not being renewed from without the machine, excludes the possi from the external atmosphere affecting the products. No cloth is confined inside the machine renders it dustless. The power required is pulley 7 in. diameter and 3½ in. face, running 600 revolutions per mi quired to drive it. The capacity of the machine as now made is equi sieve purifier.

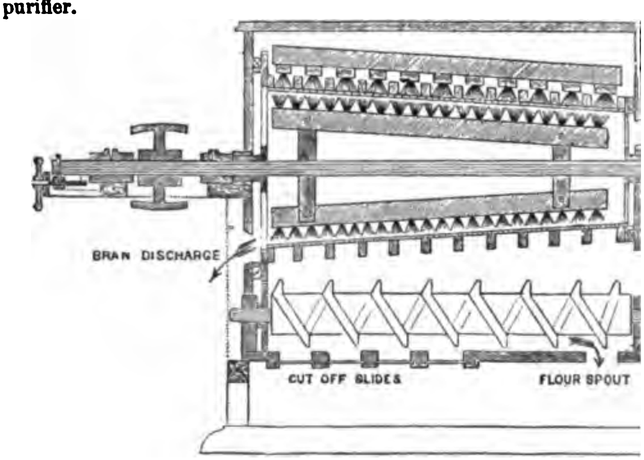


Fig. 16.—Bran-duster.

Bran-Dusters.—Economy in the production of high-grade flours cal of the bran. The effect of the bran rolls is to flatten the bran, leaving loosening the adhering particles, so that by subsequent treatment by particles are regained and further treated. The latter operation is perf

which consists of a rapidly revolving shaft on which are mounted brushes e of the shaft and made adjustable toward or from the slowly revolving surrounds them. This dusting-case, clothed with fine wire-cloth, is -shaped, the material being fed and discharged as indicated in the engraving side the wire-cloth keeps it clear, and the conveyer beneath serves to handle ng through the cloth. The shaft makes from 400 to 450 revolutions per size of machine, the pulleys 14 × 7 in. and 8 × 5 in. respectively. The given handle the offal from mills of 600 to 60 bbls. capacity in 24 hours. ence: *Gradual Reduction Milling*, by L. U. Gibson; *Flour Manufacture*, s' translation, 1888; *Die Österreichische Hochmüllerei*, by Franz Kreuter,

chine: see Key-Seat Cutters and Nut-Facing Machine.
MACHINES. HORIZONTAL SPINDLE MILLING-MACHINES.—*Universal Milling Machine.*—Fig. 1 shows a combined boring and milling machine made by the

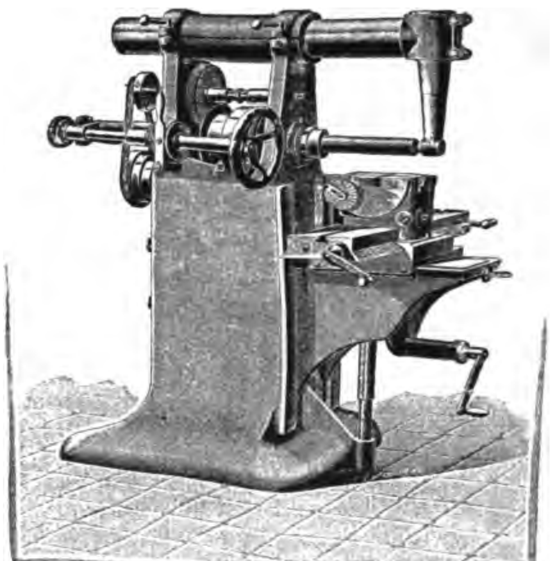


FIG. 1.—Boring and milling-machine.

s Machine Co., of Newark, N. J. The inner or boring spindle, reamed for a Morse socket, a power-feed 13 in. in both directions, and its thrust, directly from the back, is operated screw attached to it by an interlocking device. Feed is taken from a worm on the main lle and is geared to a feed-shaft for hand or power feed. This feed-shaft, on its front has a hand-wheel, giving a quick return. From there it extends to the end of the main lles, where it is geared to the feed-screw by a sensitive friction-gear, so that the power-can be set, in case a drill be dull or feed too fast, to regulate the thrust automatically, as a workman would by hand. The overhead arm supports a detachable drill-jig pendant. The platen has an adjustment graduated to ·001 in., and has deep-grooved T-slots open at either end, with a circular T-slot and attachment-seat in the center. The platen can be turned at any angle or all the way around, and fastened where desired. The knee has an adjustment up and down, graduated to ·001 in., and the saddle upon the knee has an adjustment to and from the column graduated to ·001 in. When used as a milling-machine the main spindle, 3 in. in diameter, does all the milling independent of the telescoping spindle, which does all the boring and drilling. Milling arbors and chucks screw on to the main spindle as face-plates do on lathes. The milling-feed is driven from the overhead gears, which are mounted on the milling-feed shaft, and slide into position endwise upon feathered keys; therefore

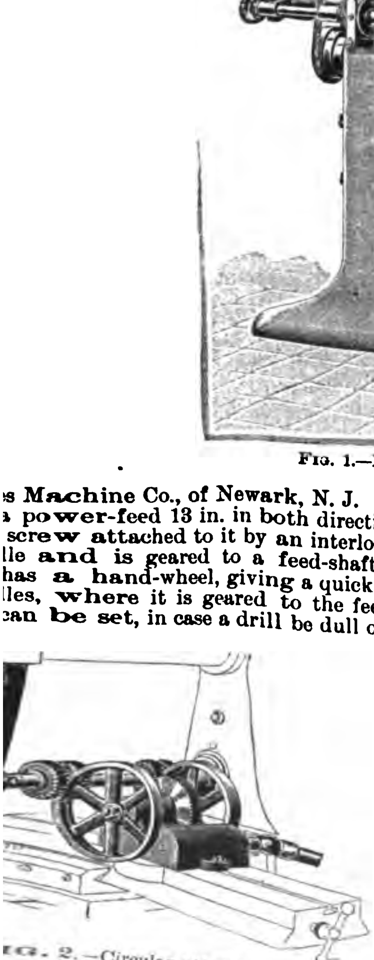


FIG. 2.—Circular attachment.

them may be engaged with the spindle-gears. The feed-shaft pulley is belted to s, and these are connected to the platen by a pair of universal joints. There are 16 of milling-feed. The platen is fed by power 24 in., and operates at angle adjust-well as the usual cross-position. The elevating, cross, and traverse adjustments are

respectively 18 in., 24 in., and 12 in. A circular milling attachment for this machine, shown in Fig. 2, is used in machining gear-blanks, balance-wheels (which are milled between the spokes as well as the periphery), pistons, and such other circular pieces as need the whole or part of their surfaces concentric to a given point. It is especially useful in duplicate work, when many parts of the same character are required.

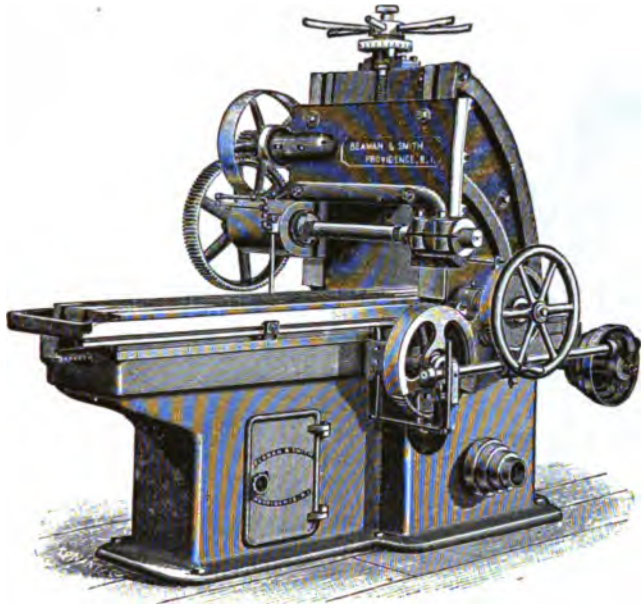


FIG. 3.—Horizontal milling-machine.

Beaman & Smith's Horizontal Spindle Milling-Machine (Fig. 3) is intended for long and heavy cuts, such as guide-bars, connecting-rods, key-seating shafting, axles to 10 in. diameter, etc. The table is 14 in. wide, has three T-slots, moves by a cut rack, and is so geared as to be easily operated by hand. The cross-head is gibbed to the housings, and is adjusted by a

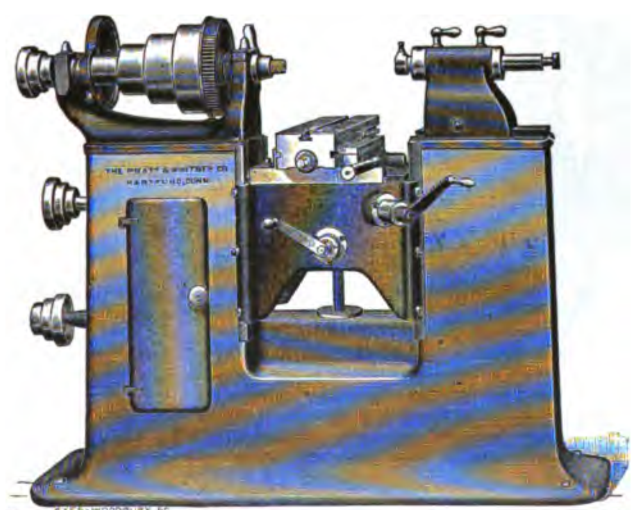


FIG. 4.—Milling-machine.

screw with graduated dial. The spindle runs in bronze bearings, is driven by a 3½-in. belt over a 16-in. pulley, through gearing in the ratio of 5 to 1, arranged for 4 speeds. Provision is made for horizontal adjustment of cutters. The feed is actuated by means of a worm and gear. It can be thrown out by hand or stopped automatically, and is the full length of the table.

[Co]lumn Milling-Machine.—Fig. 4 shows Grant's double-column milling-
the Pratt & Whitney Co. More rigidity than is possible in a single-
[o]btained in this by placing the head-stock and foot-stock on a double
[t]he elevating slide between the uprights with provision for clamping it
n use. Both vertical and longitudinal adjustments of the table may be
d of graduations in thousandths of an inch conveniently placed.
[He]ad Milling-Machine.—Fig. 5 shows a machine built by F. E. Reed, of
is designed for milling the ends of girts, beams, and a large variety of other long work. The illustration shows the machine milling loom-girts, the ends of which are 4 by $7\frac{1}{2}$ in. It is said to finish 88 of them in 10 hours. It is provided with one sliding-head, to admit of milling any length desired on both ends at the same time. The shoes in which the tables slide can be moved together or separately by means of rack-and-pinion gear. The tables have automatic feed, or can be run by hand, together or separately.

Fig. 5.—Reed's double-head milling-machine.

VERTICAL SPINDLE MILLING-MACHINES.—Milling-machines with vertical spindles and traversing or rotating tables for holding the work have come largely into use within the past few years. They offer many advantages in the range of work of which they are capable, and in the convenience and solidity with which the work is held. They are made in quite a variety of forms by different makers, much originality being shown in their design. We illustrate below several forms.

Fig. 6 represents the *Brown & Sharpe Vertical Spindle Miller.* This is a convenient machine for the various operations of milling which can be done with an end or face mill; the work being held upon the platen, and the spindle standing vertically over the same, enables the operator to plainly see or to guide the work, to follow any irregularity of outline of any raised surfaces to be milled. The platen has longitudinal and transverse movement. The spindle has a hole throughout its length, through which a bolt is passed for holding the arbors. The adjustment of the spindle is made by raising the column, a fine adjustment being obtained by a graduated collar-nut reading to thousandths of an inch. The feed is automatic at will, in either direction, stopping automatically at any required point.

The Hilles & Jones Milling-Machine.—Fig. 7 shows a new design of vertical milling-machine built by Hilles & Jones, of Wilmington, Del. It is adapted for locomotive, engine, and other heavy work. A radial crane is attached for lifting heavy pieces. The table is furnished with both rotary and traverse motions.

The Beaman & Smith Milling-Machine.—Fig. 8 represents a vertical milling-machine built by Beaman & Smith, of Providence, R. I., for surface milling, using face or end cutters from 4 to 12 in. in diameter.

[...]l Milling-Machine, shown in Fig 9, is designed for die-work, as
[...] general character hitherto done on planing and shaping ma-
[...]al, and cross feeds are provided, the latter being automatic, and
[...]ed. The head which carries the spindle is adjustable as to
[...]d. The spindle is suited for operating side, bottom, and facing

[...]hment for Milling-Machines.—This attachment (Fig. 10) is built
[...]e manufactured by Pedrick & Ayer. It is adapted to the cutting
[...], profiling, or angular milling, etc. It is secured to the head of
[...]iven by a socket fixed in the spindle, which is key-seated to fit
[...]ent. Through the medium of a pair of mitre-wheels this stud
[...]les to the vertical attachment. This spindle is geared with a
[...]s utilized as a cutter or saw arbor for cutting racks, sawing up

Locomotive Cylinder-Port Milling-Machine.—
Smith, of Providence, R. I., is designed especially

Fig. 6.—Vertical spind

It can be readily attached to any standard locomotive
to the steam-chest seat, and the uprights are move

Fig. 7.—Vertical milling-m

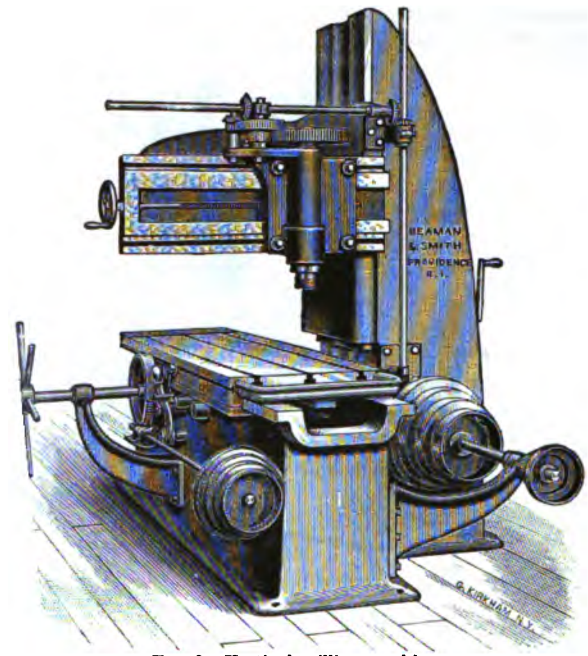


FIG. 8.—Vertical milling-machine.

ling-cutter is over the ports as desired, and are then fastened. The cross-
ndle-saddle is lowered similar to that of a planer, until the milling-cutter

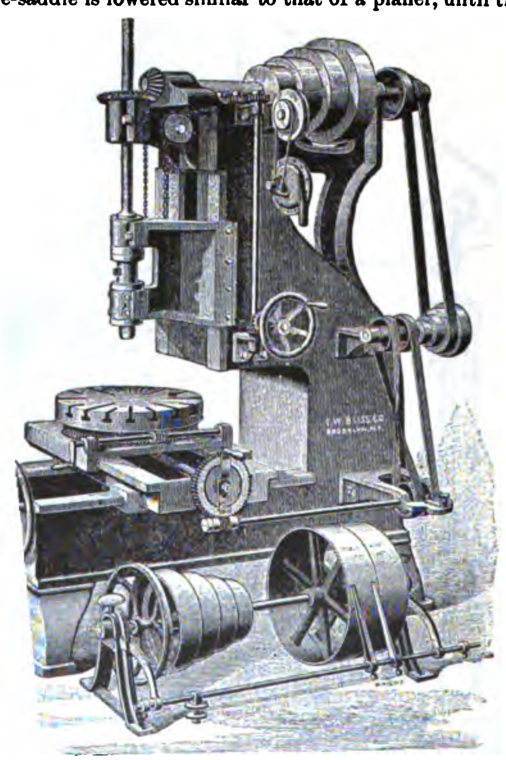


FIG. 9.—Vertical milling-machine.

then securely fastened to the uprights. The spindle is of steel,
bearings with adjustment to compensate for wear, and is driven
1atic in either direction.

MILLING-MACH

Portable Steam-Chest Seat Milling-Machine.—Fi
& Ayer, of Philadelphia, adapted to supersede the sl

FIG. 10.—Angular attachment.

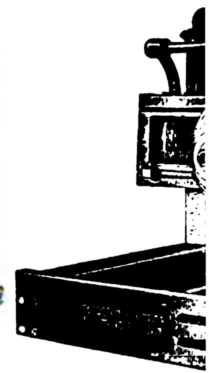


FIG. 11.—

groove in the surfaces adjoining the steam-chest sea
machine is also adapted to the drilling either of new h

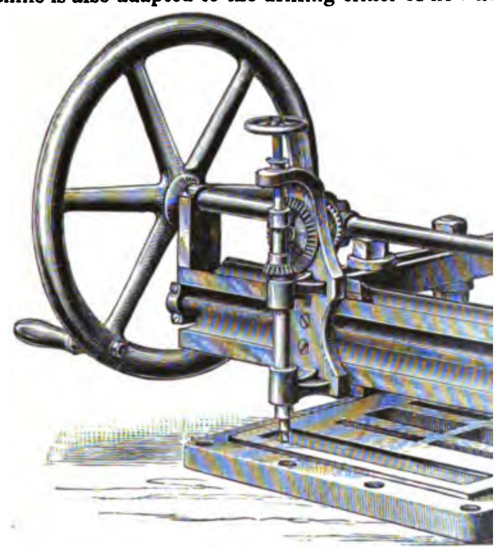
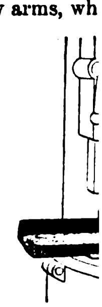


FIG. 12.—Steam-chest seat mill

studs when broken off. It is supported and adjusted
by four studs, running through two hollow arms, wh
This slide carries a head containing a spindle, similar to a drill-press, and this head receives a transverse movement by means of the screw, as shown, the milling spindle being driven by beveled gears and a transverse shaft. The cutting or grooving is performed by a face-milling cutter inverted in the end of the spindle, and is fed up and down by means of a screw and small wheel, and when the proper depth for a cut is reached the horizontal movement of the spindle is prevented by means of a check-nut on the small screw. The sliding or tool head is fed in either direction by means of change feed-gears at the end of the screw.



Leeds' Link Miller and Slotter.—This
machine (Fig. 13), built by Pedrick & Ayer, of Philad
to a heavy milling-machine or a strong drill-press. It

ed on the principle that the apex of any angle will touch or describe all hose versed sine is equal to the perpendicular where the base is formed by arc. It consists of a jointed frame having dovetailed slots running length- :ond frame that has the link-blank secured in it. The second frame is ac- :w and hand-wheel and describes a circle, according to the angular position inted frame; flanges are cast on the bottom of the frame for the purpose of the table or platen. In the center of the lower frame, at the center of the bushing that is set exactly under the center of the drill-press spindle; this support for a boring-bar and the shank of the milling-tool arbor. In prac- ıore convenient to drill a hole in one end of the link to be slotted, large ring-bar to pass through; then, by using a double-end cutter, the slot is cut) finished size. The link is then moved along ⅛ or ¼ in., and is cut through tock is removed. A milling-cutter similar to a reamer is then used, and the) the radius for which the link is set. With this attachment it is claimed that ; can be finished in about 4 hours.

'eed of Milling-Cutters.—The following table gives the speeds of milling- in American practice (see *Engineering*, December 12, 1890):

CUT ⅛ IN. WIDE.				CUT ¼ IN. WIDE.				CUT 2 IN. WIDE.				CUT ½ IN. WIDE.			
Steel.		Cast iron.		Steel.		Cast iron.		Steel.		Cast iron.		Steel.		Cast iron.	
Revolutions per min.	Feed per min.	Revolutions per min.	Feed per min.	Revolutions per min.	Feed per min.	Revolutions per min.	Feed per min.	Revolutions per min.	Feed per min.	Revolutions per min.	Feed per min.	Revolutions per min.	Feed per min.	Revolutions per min.	Feed per min.
490	4 7/16	600	5 5/8	400	3 3/8	460	4	300	2 11/16	400	3 3/4	....	....	....	....
430	3 7/8	460	4	......	......	......	....	....	......	Scale. 270	3	....	....	....	....
320	3 1/8	400	4 7/16	260	2 7/8	300	3 5/16	200	2 3/16	260	4 1/4	....	....	....	....
270	2 11/16	300	3 5/16	......	......	......	....	....	......	Scale. 180	4	....	....	....	....
245	3 7/16	300	4 5/16	200	2 13/16	230	6 1/2	150	2 1/8	200	6	....	....	....	....
175	2 7/16	230	3 1/2	......	......	150	2 1/8	....	......	Scale. 135	5	....	....	....	....
160	2 9/16	200	3 5/16	130	2 1/16	160	5 1/2	100	1 5/8	130	5	....	....	....	....
115	1 7/8	160	2 9/16	50	13/16	100	1 5/8	....	......	Scale. 90	4	....	....	....	....
120	2 1/8	150	3 1/8	100	2 1/8	120	5	75	1 9/16	100	5	70	1 1/8	80	4 1/4
85	1 3/4	120	2 1/8	40	13/16	75	1 9/16	....	......	Scale. 70	4	....	....	Scale. 60	3 1/4
80	2 1/8	100	3 1/8	70	2 9/16	80	5	50	1 9/16	70	5	45	1 1/8	55	4 1/4
50	1 9/16	80	2 1/2	25	3/4	50	1 5/16	....	......	Scale. 45	3 1/4	....	....	Scale. 40	3
65	2	80	2 1/8	50	1 5/16	60	4 1/2	40	1 3/4	50	4 1/4	35	1 1/8	40	4
40	1 3/8	60	1 7/8	20	5/8	40	1 1/4	....	......	Scale. 35	2 3/4	....	....	Scale. 30	2 1/4
40	1 1/2	50	1 9/16	35	15/16	40	3 1/4	25	3/4	35	3 1/4	20	1/4	30	3
30	0 15/16	40	1 1/4	12	5/8	25	3/4	....	......	Scale. 22	2	....	..	Scale. 20	2
45 ft. and 65 ft.		60 ft. and 80 ft.		20 ft. and 50 ft.		40 ft. and 60 ft		40 ft.		35 ft. and 50 ft.		36 ft.		30 ft. and 45 ft.	

he work will not permit the above speeds, reduce the speed of cutter in preference to

see Rolls, Metal-Working.
ee Ore-Crushing Machines.
see Clay-Working Machines.
see Saws, Wood.

LD. *Gold-Milling Machinery.*—Auriferous ores are commonly worked by the rocess. Very rich gold-ores are sometimes sold to the lead-smelters and their llected in the lead bullion; but the ores from which nearly all of the gold of ling that from placer-mines, is produced are of altogether too low grade to t manner. In the typical gold-mill the ore coming from the mine is dumped l the coarse lumps crushed by means of a Blake, Dodge, or Gates crusher to con- o as to pass a 1-in. ring. The crushed ore is fed by automatic feeders into wet- atteries, where it is crushed to that degree of fineness necessary to free the from the gangue. The stamp-batteries are lined with copper plates covered ıd as the pulp inside the battery is splashed against these plates before enough to be thrown out through the slotted steel screen, which forms one , a part of the gold is amalgamated. When the ore is crushed fine enough ıe screen, it flows down over a table of the same width as the mortar, and 8 . long, covered with copper plates coated with silver amalgam, by which

the particles of gold not already amalgamated within the mortar are caugl which has passed over the plates, always carrying a small amount of gold not economical to save, is called tailings, and is allowed to run away. The gold in ore not always free—that is, occurring in separate particles—but is sometimes cc mineral, occasionally in galena, but generally in pyrites. The gold thus containe amalgamated, and other means are necessary for its recovery. For this purpose is to save the auriferous mineral, and this is accomplished by concentrating the tailii amalgamating plates. As the tailings are generally very fine, in most cases exceedi slime-washing machines are used exclusively for concentration in gold-mills. A necessary to make one separation—that is, headings and tailings—Frue vanner's or the belt machines are admirably adapted for the purpose and are almost invar although end bump-machines are employed in some mills. The pyritic concent made are usually rich enough to be shipped to the lead-smelters, and in many districts whence freight rates to a smelting center are low are disposed of in that manner. Another method of treating auriferous pyrites, and one in which great progress has been made during the past ten years, is by chlorination. In this process the ore is roasted oxidizingly for the elimination of the sulphur, after which it is subjected to the action of chlorine gas, in covered vats or barrels, whereby the gold is converted into chloride of gold, which is soluble in water. The chloride of gold having been dissolved, the filtrate is run to suitable tubs, where the gold is precipitated by hydrogen sulphide or ferrous sulphate. The fine precipitate is dried, and finally melted into bullion. Ores containing both gold and silver, such as those of the Comstock lode, are usually treated by the process of pan amalgamation (see SILVER-MILLS), but this process is seldom used for ores carrying gold alone.

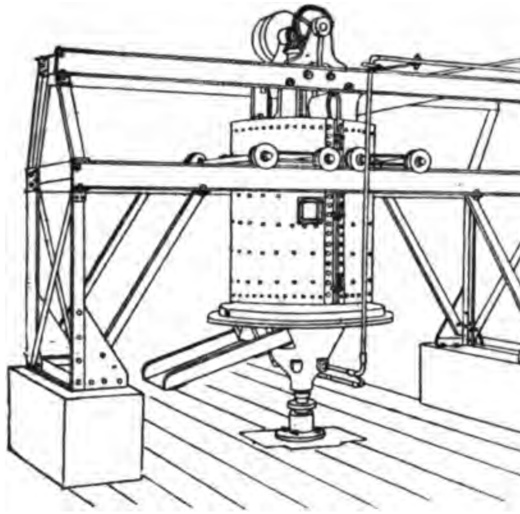


FIG. 1.—Jordan's centrifugal amalgamator.

The cost of gold-milling varies with the character of the ore, the equipment of the mill, the method of milling, etc. The lowest figure ever reached was at the mill of the Spanish Gold-Mining Co., Washington, Nevada County, Col.; there, in 1886, ore was milled at a cost of but 24·9 cents per ton. The ore consisted of about one third hard quartz, one third tough slate, and one third decomposed quartz and slate. The crushing machinery consisted of three 5-ft. Huntington mills and one 4-ft. mill, running at 60 revolutions per min., consuming 22 horse-power, and discharging through a No. 6 slot screen. In a 4-months' run, 19,402 tons of ore were crushed; the averaging cost of milling being, as before stated, 24·9 cents per ton, divided as follows: Labor, 9 cents; water, 3·6 cents; shoes, 2·9 cents; screens, 1·3 cents; dies, 1·7 cents; caps, scrapers, and bolts, ·2 cent; renewal of working parts, 2 cents; quicksilver (at $40 per flask), ·5 cent; oil for illumination and lubrication, ·2 cent; labor at rock-breaker, 2 cents; wear and tear of rock-breaker, ·5 cent; depreciation, 1 cent. Later the cost was further reduced to 20·8 cents per ton, of which 11·8 cents was for labor and 9 cents for supplies. The ore which was worked at this mill averaged only 65 cents per ton, and was actually mined and milled for 52 cents per ton, the mine being opened as a quarry and worked under extremely favorable circumstances. The foregoing figures are from statements by Mr. F. W. Bradley, the superintendent of the company. The Plymouth Consolidated Gold-Mining Co. milled ore in 1886 at an expense of 39 cents per ton, and saved and reduced the sulphurets at an additional expense of 17 cents per ton of ore. The Plumas-Eureka Mining Co. milled ore in 1888 at an expense of 58½ cents per ton, and in the same year the cost at the Yuba and Hanks mills of the Sierra Butte Gold-Mining Co. was but 26½ cents and 35 cents per ton, respectively. In Montana, in 1888, at the 60-stamp mill of the Montana Co., Limited, low grade gold-ore was crushed and amalgamated on plates, and the sulphurets concentrated on Frue vanner's at a cost of $1.13 per ton. At the large mill of the Alaska-Treadwell Gold-Mining Co., Douglas Island, Alaska, the cost of milling ore and concentrating sulphurets, for the year ending May 31, 1891, was 42·06 cents per ton, of which 19·4 cents was for labor and 22·66 cents for supplies. At the Golden Star mill (120 stamps) of the Homestake Mining Co., at Lead City, South Dakota, the cost of milling in 1887–'88 was, according to Mr. H. O. Hofman, 82·92 cents per ton. The best practice in gold-milling in this country at the present time is undoubtedly that of California. McDermott and Duffield state that, on a considerable variety of gold-ores in that State, the percentage of gold saved averages

cent, and careful daily tests in some of the best gold-mills using concen- 85 to 90 per cent.
lorination works in the world are at the famous Mount Morgan mine in re a modification of the Newberry-Vantin process of barrel chlorination is eraged, as worked, 5 oz. gold per ton, and 1,800 tons were treated per week, are said to contain only 3 dwt. gold per ton, which, if correct, represents a cent. The cost of the process on this large scale is given as $7.50 per ton. es that the cost of chlorinating at the Haile Mine, Lancaster County, North 4 per ton of roasted ore, divided as follows: Roasting, $2.62½; chlorinating labor, 95 cents; chemicals, 60 cents), $1.67½; ferrous sulphate for precipitat- pairs and wear, 20 cents; total, $4.62½. This is equivalent to $3.47 per ton of figures have been published concerning the cost of chlorination in the the Haile figures have probably been exceeded, owing to the larger tonnage standing the higher cost of labor, fuel, and supplies.
ATORS.—A large variety of mechanical amalgamators, to take the place of cop- have been invented, but none have come into very general use. These ma- generally pans or cylinders in which the pulp is rotated with mercury, the object ring the particles of gold in more intimate contact with the mercury than on the

n's Centrifugal Amalgamator (Figs. 1, 2) consists of a series of shallow dishes, attached w another to a central revolving shaft, and inclosed in a fixed circular casing. Secured to the inner side of the cas- ing, and alternating with the dishes, are slightly inclined shelves, also amalgamated. The pulp fed into the amal- gamator enters the first dish, in which it is revolved until impelled by the centrifugal motion over the edge of a dish. It then falls on one of the shelves and is thus con- veyed to the center of the second dish, there to under- go similar treatment. This is repeated to the end of the series, where the tailings es- cape. The free gold and sil- ver contained in the pulp are arrested by the amalgamated dishes and shelves, which are scraped at suitable intervals and the amalgam retorted.

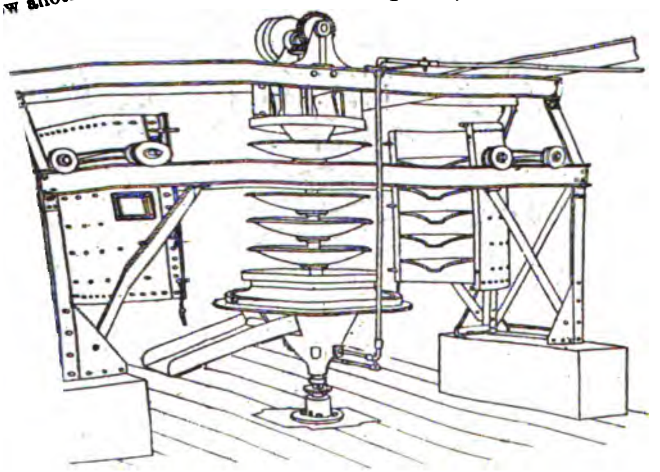


FIG. 2.—Jordan's centrifugal amalgamator.

The Cook Amalgamator (Fig. 3) consists of a horizon- tal iron cylinder *A*, with an spiral rib, rotated about 30 times per min. The spirals *e* form a channel 40 ft. long, vide the material and keep it divided all the way through the cylinder. The ro- tion spreads the pulp and subjects it to a rolling motion in the water, the gangue ead of mineral ⅓ of the distance over amalgamating surface *E*, and ⅔ over non-amalga- surface *e*, which al- ls enough mercury to nalgamate free min- ting the whole dis- lgamating with only nating surface. The s separated from the nalgamated and col- o little bunches of in cylinder, and as passes to the tables . The tables have ious amalgamating the mercury-wells amalgam is col- ate *h* spreads the which passes under s up from gate-well wn down by splash- table *H*, thence on indicator *J* and discharge-spout *o*. The tailing-indicator consists of two amalga- tes on which the tailings drop: these plates indicate, collect, and deposit, it is said, any possible loss of amalgam or mercury from the machine. According to the

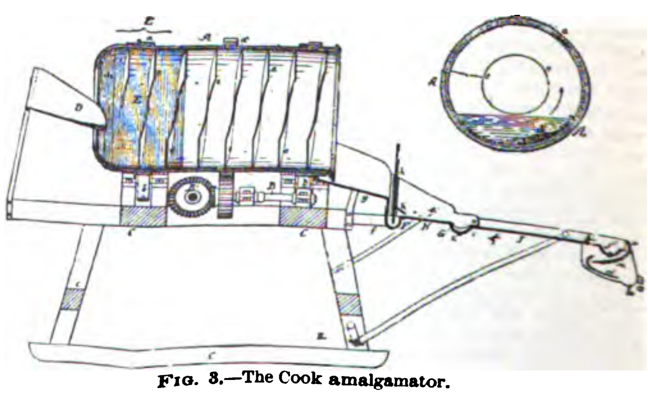


FIG. 3.—The Cook amalgamator.

manufacturers, a cylinder 7 ft. long and 3 ft. in diameter
stamps. It requires 18 gals. of water per min., and ½ hors

CHLORINATION MACHINERY.—The chlorination barrel us
tion Works, Deadwood, S. D., the methods employed at w
practice in barrel chlorination, is thus described by Mr. *Joh*
and Mining Journal, vol. li, 165, 166: The chlorination bar
serve at the same time as the washing and leaching vessel, b
to form the chord of an arc of the circle of the barrel. The
is made up of corrugated plates, and perforated with holes
plates are supported on segments which are bolted to the sh
corrugated plates is placed the filtering medium, an open-wo
placed an open grating, and the whole is held in place by cro
under straps bolted to the inside shell; in this way, while the
it is very easily and quickly removed when the changing
necessary. Two valves on each end of the barrel above and b
and outlet of the wash-water and solution, respectively. The
the space under the filter with water, which at the same time
filtering medium and wash it; then the required quantity of
There are now two methods of charging the pulp and the chemi
acid). In one, the lime is so placed in the ore charge in the
goes in with the ore and is completely buried with it; the aci
little danger of generating any gas before the plate on the ch
securely fastened. The other way, which seems to be still bet
the water, through which it sinks in a mass to the bottom and
let in, and the lime added the last. The chances of wasting
the first method. On the first revolution of the barrel the ga
creates considerable pressure. After the chlorination is com
that the filter assumes a horizontal position; the hose is attac
and conducts the solution to the reservoir tank. A hose is a
and water is pumped in under pressure, and the leaching co
part of the barrel is compressed and forms an elastic cushio
perfect freedom to circulate evenly over the whole surface of th
of it thoroughly and with the smallest quantity of water possib
to do the leaching varies with the leaching quality of the ore
leached in 40 min. with a pressure of from 30 lbs. to 40 lbs. pe
the time can be materially shortened. In order to facilitate t
an excess of slimes, a valve placed in the head of the barrel, o
pulp, is opened just after the barrel is stopped, and the du
suspension are run off into an outside washing filter-press, wh

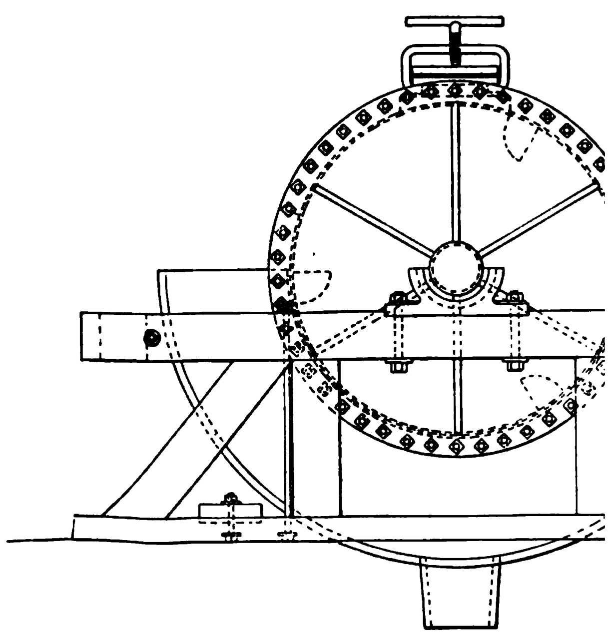


FIG. 4.—The Thies chlorinating barr

The tailings are discharged into a car which will hold the who
then run out; or, if water is abundant, they are discharged i

... that the speed which is required to make some small motors act as self- ... is so high as to render that application mechanically impossible. ... According to Kapp, that in small motors the polar surfaces are of ... consequently the magnetic resistance of the path traversed by the lines of ... high, requiring more electrical energy to excite the field magnets ... capable of developing at a moderate and practical speed.

... and connected for working as generators of continuous currents may be ... motors, but with some difference. A series dynamo set to generate cur- ... right-handedly (and therefore having a forward right-handed lead), will, ... a current from an external source, run as a motor, but runs left-handedly. To set it right for motor purposes requires either that the connections ... should be reversed, or that those of the field magnet should be reversed (in ... it will run right-handedly), or else the brushes must be reversed and ... the direction (in which case it will run left-handedly). A shunt dynamo, ... as a generator, will, when supplied with current, run as a motor in the ... as a generator; for if the current in the armature part is in the same ... that in the shunt is reversed, and *vice versa*. A compound-wound ... run as a generator, will run as a motor in the reverse sense, *against* its ... part be more powerful than the shunt, and *with* its brushes if the shunt ... ful. If the connections are such (as in the compound dynamos) that ... gives the sum of the effects of the shunt and series windings when used ... will receive the difference between them when used as a motor.

... it is even more important that the rules laid down for the good design ... (Dynamo Electric Machines) should be observed for motors. Eddy ... more carefully eliminated. According to Mordey, in a generator the ... sections of the armature coil, and the eddy currents in the core, are ... motor they tend to increase one another. Also, the greatest attention ... mechanical arrangements for transmitting to the shaft the forces ... magnetic field upon the conducting wires around.

... ors.—One of the earliest attempts to secure an automatic regulation ... of M. Marcel Deprez, who in 1878 applied an ingenious method of ... at a perfectly regular rate by introducing a vibrating brake into the ... perfectly uniform speed, quite irrespective of the work it was doing. ... the torque of a motor depends only on the strength of the field and on ... not depend on the speed. In dealing with this matter, in *La Lumière* ... 1885, he says: "If a current traverses a motor having an armature ... the turning effort of the latter is independent of its state of move- ... tion it is independent of the speed, provided the strength of the cur- ... stant. Inversely, if the static moment tending to resist the motion ... maintained constant, the current will thereby automatically be kept ... means we may employ to vary it. Since with a constant load the ... proportional to the speed, and since the electrical energy supplied to the ... current and electro-motive force, it follows that if the current is ... be proportional to the electro-motive force."

... *Governing*.—It was pointed out (see Dynamo Electric Machinery) that a ... shunt-wound dynamo, if run at constant speed, would generate a *constant* ... Conversely, it can be shown that a shunt-wound machine, if supplied ... at a constant potential, will maintain *constant* speed at all loads. ... majority of motors in use at present are of the shunt-wound type, ... potential circuit, as they regulate automatically. ... motors can be governed by compound winding of the field magnets; ... series coil must be wound differentially to the shunt winding to maintain ... method is claimed by Sprague and Ayrton and Perry. With this ... coil in series with the armature tends to weaken the field magnet- ... load.

... *Governing*.—Professors Ayrton and Perry have also proposed several forms ... centrifugal governor, a device by which, in every revolution, power is sup- ... of the revolution only, the proportion of the time in every revolu- ... power is supplied being made to vary according to the speed. The ... such governors is to prevent sparking. But there is a still more ... centrifugal governors; they all work too late. They do not perform ... the speed has changed.

... *Governing*.—Prof. S. P. Thompson has devised another kind of gov- ... to this objection. He proposes to employ a dynamometer on the ... actuate a regulating apparatus, which may consist either of a periodic ... interrupt the current during a portion of each revolution, or of an ... connected in part of the circuit. The regulator in this case is ... according to the speed of the motor, but according to the load it is ... in the load will instantly act on the dynamometric governor before ... change.

... *Governing*.—Sprague and André have designed motors in which ... wound in two separate circuits, one with thick and the other with ... dividing between them, and the armature connected as a bridge across

...of governing, and the nature of the circuit to which it is connected. This is well ...in the accompanying tables, due to Dr. S. S. Wheeler and Prof. F. B. Crocker, which ...espectively the efficiencies of machines (shunt wound) connected to constant-potential ...s, and machines (usually series wound) connected to constant-current or arc-light cir... and the currents required at the various potentials.

...es required to give Different Powers on the Various Constant-potential Circuits, allowing for the Ordinary Efficiency of each Size of Motor.

Efficiency of motor.	Electrical horse-power required.	8 volts battery.	50 volts.	75 volts.	100 volts.	110 volts.	120 volts	220 volts.	240 volts	440 volts.	500 volts.
40%	·16	14	2·3	1·6	1·2	1·1	1·	·53	·48	·26	·23
55	·23	21	3·4	2·2	1·7	1·5	1·4	·76	·69	·38	·34
60	·23	26	4·1	2·8	2·1	1·9	1·7	·95	·87	·48	·41
62	·40	38	6·0	4·0	3·0	2·7	2·5	1·4	1·3	·68	·60
66	·76	71	11·3	7·5	5·7	5·1	4·7	2·6	2·4	1·3	1·13
72	1·4	130	20·7	13·8	10·4	9·4	8·6	4·7	4·3	2·4	2·07
75	2·7		39·8	26·6	19·9	18·1	16·5	9·1	8·3	4·5	3·98
78	3·8		57·8	38·2	28·6	26·	23·8	13·0	11·9	6·5	5·78
79	5·0		75·5	50·3	37·7	34·3	31·4	17·2	15·8	8·6	7·55
80	6·2		98·3	62·2	46·6	42·4	38·8	21·2	19·4	10·6	9·33
82	9·1		136·	90·9	68·2	62·	56·8	31·0	28·4	15·5	13·6
84	12·		178·	118·	88·8	80·7	74·	40·4	37·	20·2	17·8
85	17·6		263·	176·	132·	120·	110·	60·	55·	30·	26·3
86	23·		347·	231·	173·	158·	145·	79·	72·	39·9	34·7
88	28·		424·	283·	212·	193·	177·	96·	88·	48·2	42·4
88	34·		509·	339·	254·	231·	212·	116·	106·8	57·8	50·7
89	40·		587·	391·	293·	266·	244·	138·	122·	67·4	59·
89	45·		671·	447·	335·	305·	280·	153·	140·	77·	67·
90	55·		829·	553·	414·	377·	346·	188·	172·	94·	83·
90	83·		1,243·	828·	621·	565·	518·	283·	259·	141·	124·

...required to give Different Powers on Various Arc Circuits, allowing for the Ordinary Efficiency of each Size of Motor.

...ower of ...or.	Efficiency of motor.	Electrical horse-power required.	3 amperes.	6½ amperes.	10 amperes.	18 amperes.
[illegible]	35%	·18	44·	20·	13·	7·
[illegible]	50	·25	62·	29·	19·	10·3
[illegible]	55	·45	112·	51·	34·	18·7
[illegible]	62	·81	201·	93·	60·	33·5
1	68	1·47	366·	169·	110·	60·9
2	72	2·8	696·	319·	207·	115·
3	76	4·0	981·	453·	294·	163·
4	77	5·2	1,291·	596·	387·	215·
5	78	6·4	1,594·	736·	478·	265·
7½	79	9·5	2,360·	1,080·	708·	393·
...0	80	12·5	3,108·	1,435·	983·	518·
...5	82	18·3	4,548·	2,099·	1,364·	758·
...0	83	24·1	5,991·	2,765·	1,797·	999·
...5	84	29·8	7,400·	3,416·	2,220·	1,233·
...0	85	47·1	11,700·	5,400·	3,510·	1,950·

...examination of the tables shows that the efficiencies range from 35 to 90 per cent., which ...red with the steam engine, shows considerable superiority. The consumption of coal ...m engines of various sizes and types, varies from 2 to 10 lbs. per horse-power hour, a ...ion of 1 to 5 against 1 to 2 with electric motors. Further consideration shows that the ...t of energy required to produce a given amount of power is not affected by the size of ...otor, within moderate limits; the gain in efficiency, if an unnecessarily large motor is being about offset by the losses due to its not being fully loaded. For instance, if one ...power is obtained from a two-horse-power motor, the motor itself, being larger, will be ...htly greater efficiency; but not being run at its best load, the result will be only about ...ne as if a one-horse-power machine were used. In other words, for any given amount ...rer consumed, the amount of energy required, and, therefore, the cost of running, is ...ally constant and independent of the size of the motor used, within the ordinary limits ...ection. This, however, refers merely to the cost of current, and is not to be under... as lessening the imperative importance, for mechanical reasons, of choosing a motor considerable margin of capacity.

etic poles in the armature are always a little in front of those in the field magnet. atter, therefore, are, as it were, perpetually running after the former, but never catch- em. From the peculiar construction of the Ayrton and Perry motor, it may be oper- ithout any wire at all upon the revolving field magnets. This arises from the fact e magnetism in the stationary armature induces opposite magnetism in the iron of

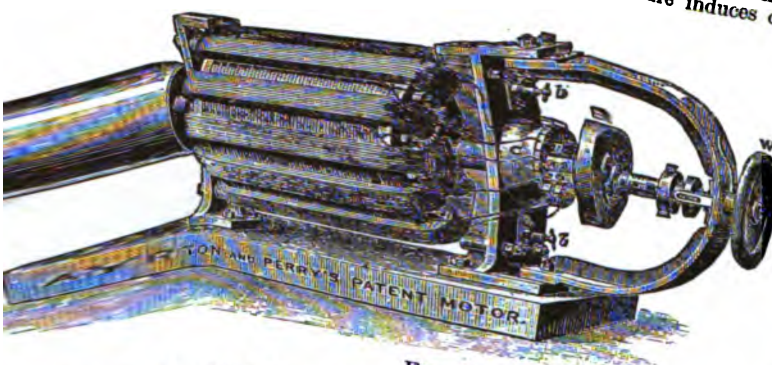


FIG. 2.

Ayrton and Perry motor.

FIG. 3.

e field magnets, and, as pointed out before, the brushes are so placed that the magnetic les in the armature are always just in front of those in the iron, which latter are always nning round after those in the former, but never catch up with them.

The Griscom motor is remarkable for the small space it occupies, due to its neat and compact design, shown in Fig. 4. The armature is entirely encased by the cylindrical electro-magnet within which it revolves, and by the metallic caps or disks fitted to this cylinder at each end. The cylindrical field magnet is composed of a cylinder of soft iron wired in two large coils, each of which covers nearly one-half of the cylinder, the space left between the two coils at opposite sides of the cylinder constituting the magnetic poles of this cylindrical electro-magnet. The current which passes through the wire on this magnet circulates in opposite directions in each coil or section, so that both coils combine to produce a north pole in one of the open spaces, and a south pole at the other. The result is practically the same as if two U electro-magnets were brought together with like poles in opposition, these forming a circular magnet with two consequent or combined poles, one at each junction. The iron of the cylindrical magnet projects laterally at each pole, and to these projections an ornamental brass disk is screwed firmly at one end, as shown in the figure. The binding post shown at the top is prolonged on the other side of the metallic cap, and carries one of the brass springs or brushes which serve to convey the current to the armature by pressing on the commutator. The other brush, touching on the opposite side of the commutator, is held in place by a special screw device attached to the metallic cap. The armature and the field magnet e connected in series. The current, entering the upper commutator ring, leaves it by the lower, from which it passes to the field magnet, whence it goes to the ond binding post.

FIG. 4.—Griscom motor.

To this department of electricity, as well as to the use of motors on railways and street- lines, Mr. Leo Daft has paid considerable attention. Fig. 5 shows a Daft motor of the form. The field magnets are made after what is called the Siemens plan—that is, they orizontally, have consequent poles, one above, and the other below, the armature. They ries wound, but the coils of the field magnets are divided, so that there are two or more ts around the core. By suitable devices these are so related that they can be thrown ries or into multiple arc, or into other combinations when there are more than two for the purpose of changing the strength of the magnetic field, to suit the electro- rce and strength of current supplied to the motors. The armatures are modeled in fter the Gramme, but their construction is much improved, especially in respect ner of mounting them on their shafts. st form of Daft motor is shown in Fig. 6. It will be seen that the field magnets mple horseshoe form, and that the armature is of the Gramme type, as in Mr. is models. The machine is designed to deliver normally 6 horse-power, but s been driven to as high as 11 horse-power without injurious effect. er Manufacturing Co.'s exhibit in the International Electrical Exhibition n 1884 were seen several sewing machines run by various electric motors

e hub, and the brushes on the magnets bear against the segments.

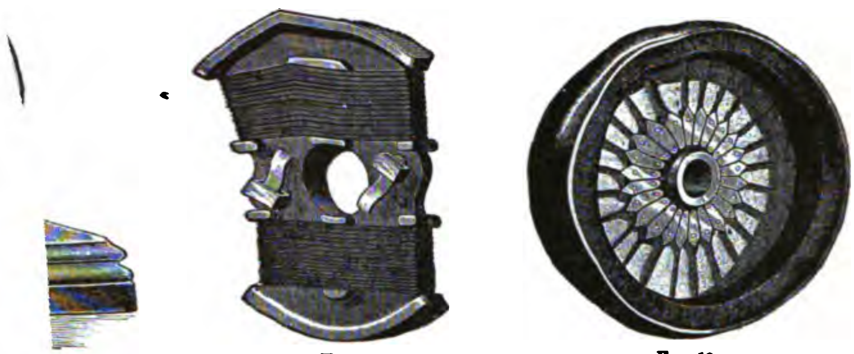


FIG. 9. FIG. 10.

FIG. 8–10.—Diehl motor applied to sewing machines.

to the motor pass up through the hollow casting of the frame, and are tch, by which the machine can be started and stopped at will. The fly-wheel is provided with a clutch or stop motion in connection with the shaft, so that it may be connected with the latter, or turned loose, as is common in sewing machines—the wheel being disconnected from the shaft when winding bobbins. This is accomplished by a turn of a thumb-nut at the rear end of the machine. By unscrewing this nut entirely, the armature may be slid out completely, so that it may be examined, should necessity require. This also exposes the field magnets and brushes, so that they can be easily gotten at for examination and attention.

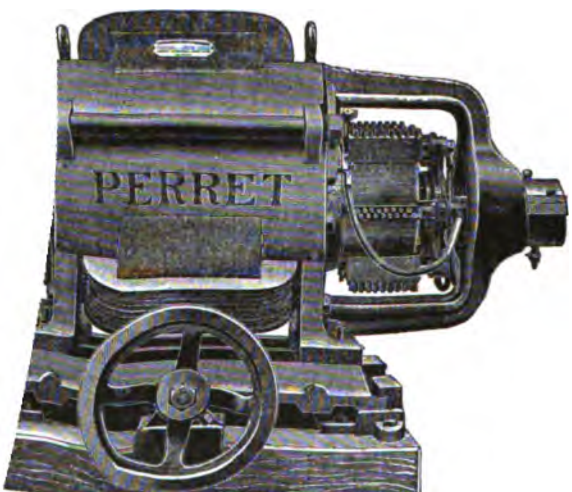


FIG. 11.—Twenty-horse-power motor.

The chief distinctive feature of the motors de- rank A. Perret is the lamination of the field magnet, which is built up out of of soft charcoal iron, stamped their finished form, and clamped y bolts in such a manner as to it mechanical strength. The ar- e is also laminated, and the plates which form longitudinal channels phery, in which the coils are wound. a side view of a 20 horse-power motor Fig. 12 is a cross-section of magnets ture showing magnetic circuit. It en that the armature is a ring of com- large diameter, with longitudinal on its periphery, in which the conduc- wound and thus embedded in the iron, in such close proximity to the iron pole hat there is practically no gap in the c circuit. The field consists of three magnets arranged at equal distances the armature, each magnet having two ces. The winding is such as to produce

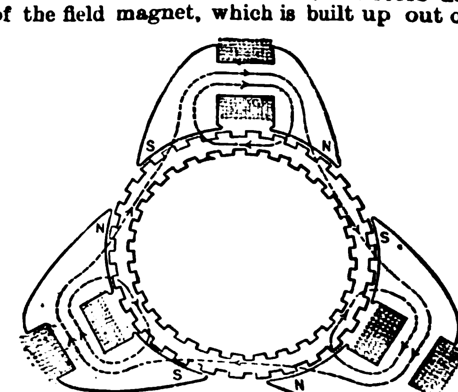


FIG. 12.—Perret motor. Cross section.

…at the hub, and the brushes on the magnets bear against the segments.

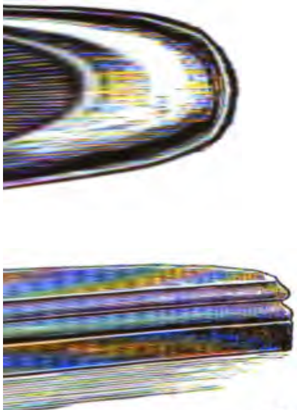


Fig. 9.

Fig. 10.

Fig. 8–10.—Diehl motor applied to sewing machines.

…the motor pass up through the hollow casting of the frame, and are …by which the machine can be started and stopped at will. The fly-wheel is provided with a clutch or stop motion in connection with the shaft, so that it may be connected with the latter, or turned loose, as is common in sewing machines—the wheel being disconnected from the shaft when winding bobbins. This is accomplished by a turn of a thumb-nut at the rear end of the machine. By unscrewing this nut entirely, the armature may be slid out completely, so that it may be examined, should necessity require. This also exposes the field magnets and brushes, so that they can be easily gotten at for examination and attention.

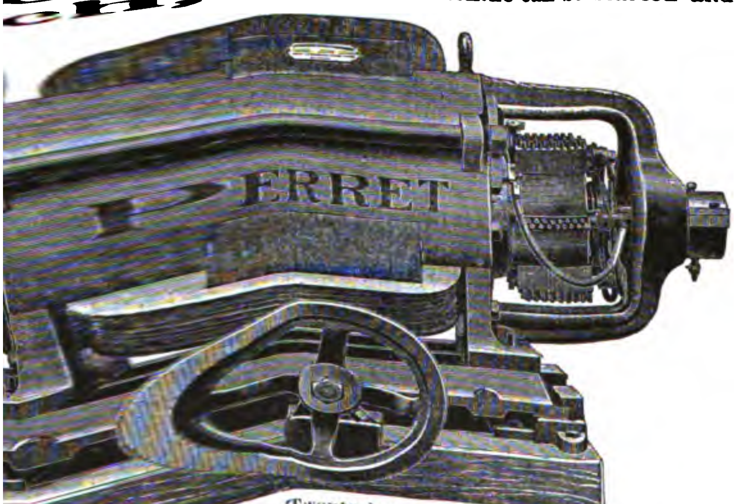


Fig. 11.—Twenty-horse-power motor.

The chief distinctive feature of the motors de… A. Perret is the lamination of the field magnet, which is built up out of …ank of soft charcoal iron, stamped of their finished form, and clamped …y bolts in such a manner as to …t mechanical strength. The armature is also laminated, and the plates … which form longitudinal channels …iphery, in which the coils are wound. …a side view of a 20 horse-power motor. Fig. 12 is a cross-section of magnets showing the magnetic circuit. It …nature the armature is a ring of com… seen that … diameter, with longitudinal …rely large periphery, in which the conduc…els on its … …re wound and thus embedded in the iron, …n is in such close proximity to the iron pole …s that there is practically no gap in the …netic circuit. The field consists of three …rate magnets arranged at equal distances …und the armature, each magnet having two …e pieces. The winding is such as to produce

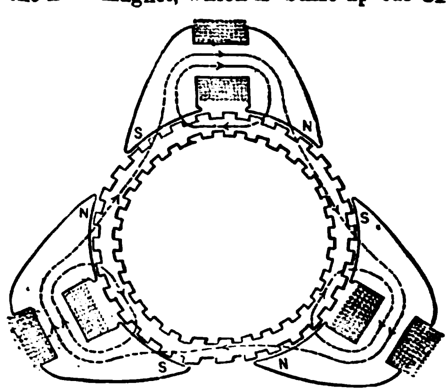
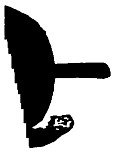


Fig. 12.—Perret motor. Cross section.

r, or the reverse. At the same time the brushes on the commutator run
not shifted in position during extreme changes of load on the motor.
n-sparking points of the commutator remain at one position without



ture.

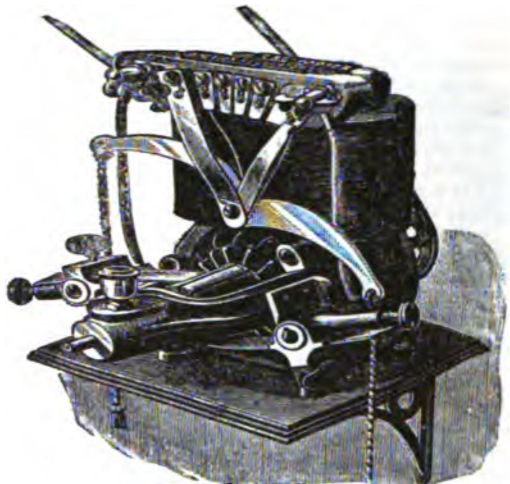


FIG. 17.—C. & C. motor.

in Fig. 18, the poles of the field magnets—the bodies or cores of
—project upward and enclose the armature, the section of the core
The winding of the armature is a modified Siemens arrangement,
are in shunt to the armature. The armature core is so well lam-
f the armature conductor is so low, that loss by Foucault currents,

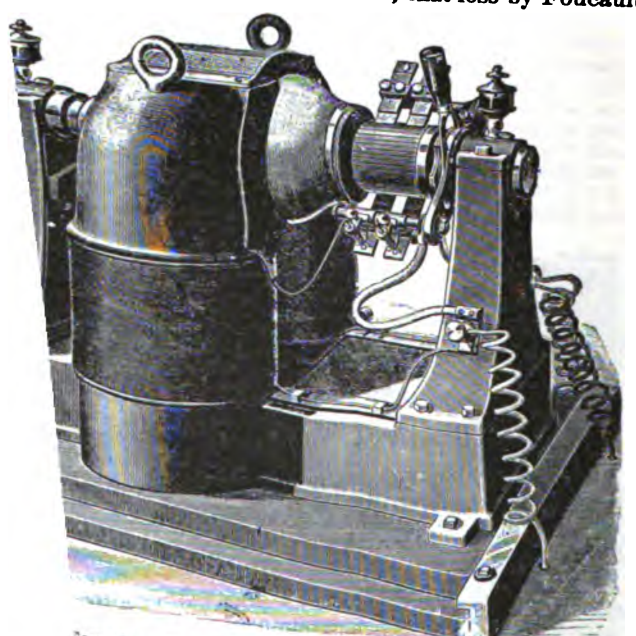


FIG. 18.—Thomson-Houston motor.

by internal resistance, is very light as compared with the

vas designed by Mr. William Hochhausen to regulate and
ariable load, with fixed brushes and without the interposi-
as a single magnetic circuit, in which the armature is in-
d by varying the intensity of the magnetic field to corre-

…ne of stroke. In both cases there can be no dead point, and the motion is smooth …ntinuous.

…e Brush motor, which is illustrated in the engraving, Fig. 24, closely resembles the … dynamo, but the devices added to the machine for the purpose of securing steadiness

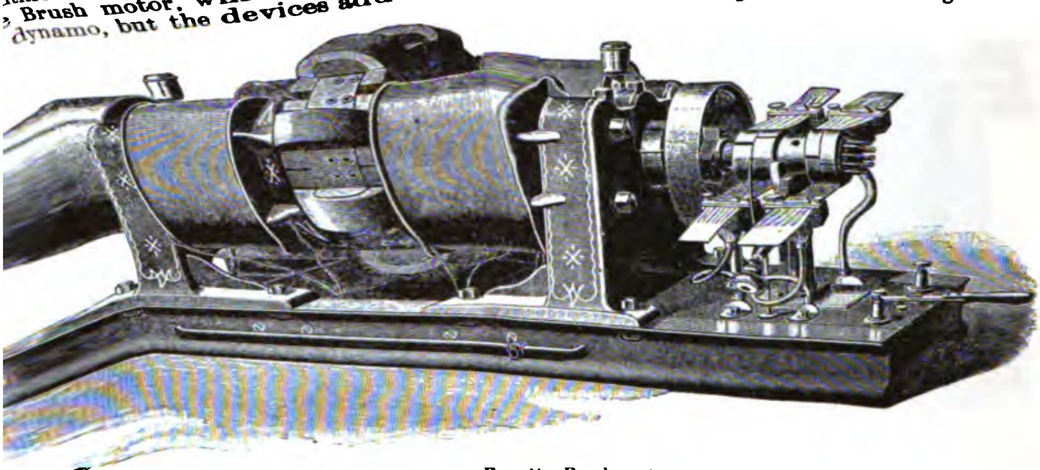


FIG. 24.—Brush motor.

power and constancy of speed under all loads merit a detailed description. It will be seen that, mounted on the shaft between the commutator and the journal bearing, there is a cylindrical shell. This shell contains the governor by which the speed of the motor is maintained constant. The mode of regulation adopted by Mr. Brush consists in causing the governor to adjust the commutator automatically with relation to the brushes. To this end the commutator segments are mounted upon a sleeve on the shaft, so that they can be revolved to any desired extent under the influence of the governor.

The illustration, Fig. 25, shows the governor in detail. As will be seen, the commutator brushes, *C C*, remain fixed, and loosely mounted on the shaft, *E*, is the commutator sleeve, *a*, which turns freely. The commutator sections, *d*, are insulated from the sleeve, *a*, and are connected to the armature bobbins by flexible wires, so as not to interfere with the rotary adjustment of the commutator. To the inner periphery of the cylindrical shell, *G*, which is bolted to the shaft, the governor arms, *H H*, are pivoted. The inner free ends of the arms are connected to the opposite arms by means of spiral springs, *I I*. In addition, the arms carry each an adjustable weight, *K*. The links, *L L*, attached to the arms, *H H*, are connected to a disk upon the commutator sleeve. Hence, it will be readily understood that as the governor shell rotates with the pivoted weights, *K K*, the latter, by centrifugal force, will be removed toward the periphery of the shell, and, through the medium of the connecting links, *L L*, will impart a rotary movement to the commutator, varying its position on the armature shaft.

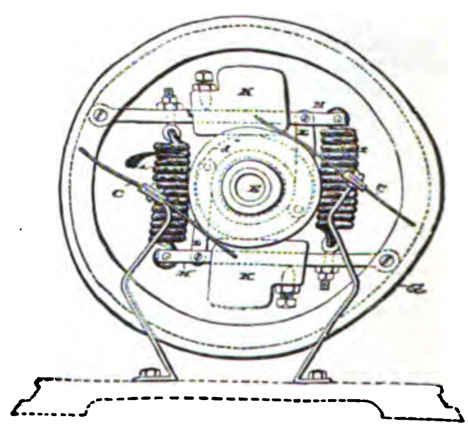


FIG. 25.—Governor of Brush motor.

The action of the governor is precisely analogous to that in a steam engine. When in a state of rest, the springs draw the weights toward each other and maintain the commutator segments at the maximum point of effect with relation to the brushes. When current is switched on to the motor, the governor weights in their revolution are thrown outward and rotate the commutator, carrying the maximum points away from the contact points of the brushes and in the direction of rotation of the armature. This action decreases the effect of the driving current until a point is reached where the effect of the driving current is balanced by the load on the motor, and the speed of the latter remains constant. Now, should the speed of the motor be retarded by a decrease of current strength with no corresponding diminution of load, or by an increase of load with no increase of current strength, the governor balls will be retracted and drawn toward each other by the spiral springs, and thereby rotate the commutator in a direction opposite to the motion of the armature shaft, the effect of which is to move the maximum points on the commutator nearer to the brushes, and thereby increase the speed of the motor. On the other hand, should the speed of the motor

.ls in series with the armature, and depending upon it, which
'hich is opposed to that of the main coils of the machine.
rranging these coils, known as the long, the short, and the
long shunt is shown in Figs. 30, 31, and 32. By making these
on in the field, and working with nearly a straight-line char-
onstructed on certain laws known as Sprague laws.
ce of the main or shunt field coil; *m*, the number of turns
.e differential or series field coils; *n*, the number of turns, and

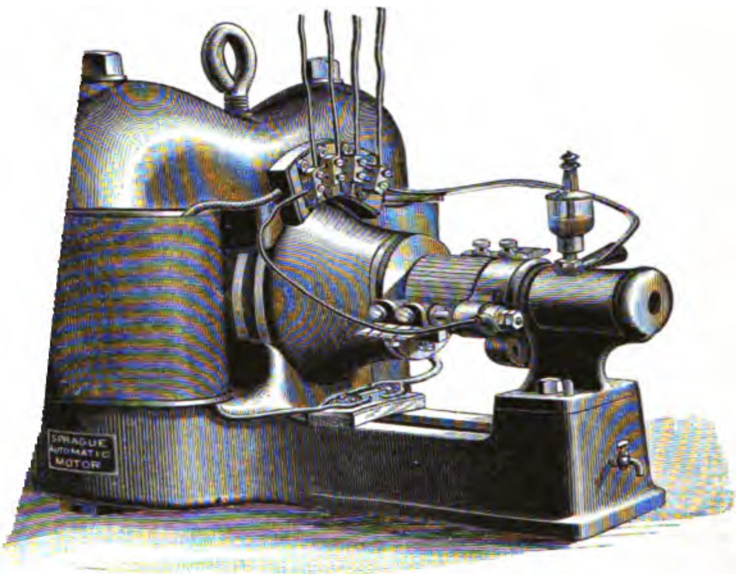
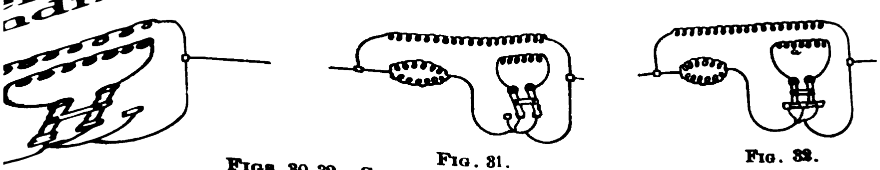


FIG. 29.—Sprague motor.

[th]e armature. Then for the long-shunt machine, the law of winding is
[equa]tion, $\frac{m}{n} = \frac{f}{R + r}$; that is to say, the number of turns in the shunt
[sa]me ratio to the number in the series coil, as the resistance of the shunt
of the resistances of the series coil and the armature. In the short-
law of windings is expressed as follows: $\frac{m}{n} = \frac{f + R}{R}$; that is to say, the
the shunt field must bear the same ratio to the number of turns in the
[fie]ld, as the sum of the resistances of the shunt field and the armature
ce of the armature.
ings the motor will regulate itself perfectly at all potentials so long as
with a straight-line characteristic, but it must be with an electric effi-
[pe]r cent. A peculiarity in motors wound according to this method is that
[st]anding still, and current is admitted to it with the circuits normally ar-



30. FIG. 31. FIG. 32.

FIGS. 30-32.—Sprague shunt regulator.

of the two coils is equal and opposite, and there will be no field excita-
[i]ty led to the introduction of a short-circuiting or reversing switch, which
series coil in starting the machine, or reversed it, making it a cumulative
ur-pole machine designed by Mr. Sprague, more interesting from a scien-
cal standpoint, now that motors have been raised to such high degrees of
rted winding was adopted, the series coil being put on two diagonally situ-
magnet; this resulted in distorting or shifting the resultant consequent
on opposite to the distortion set up by the armature. The object of this
brushes at a fixed non-sparking point. In one railroad machine built by
is action was carried still further, the field magnets being wound with field

nents, of which there is one for each helix: and the other
common union, insulated from and carried upon the shaft.
glish manufacture, and embodies some novel features, espe-
Fig. 36 is a perspective view of the machine, and Fig. 37 s
diagram only eight coils are indicated, although 48, 96, or
mmutator is of the bisected type, and the coils are joined to

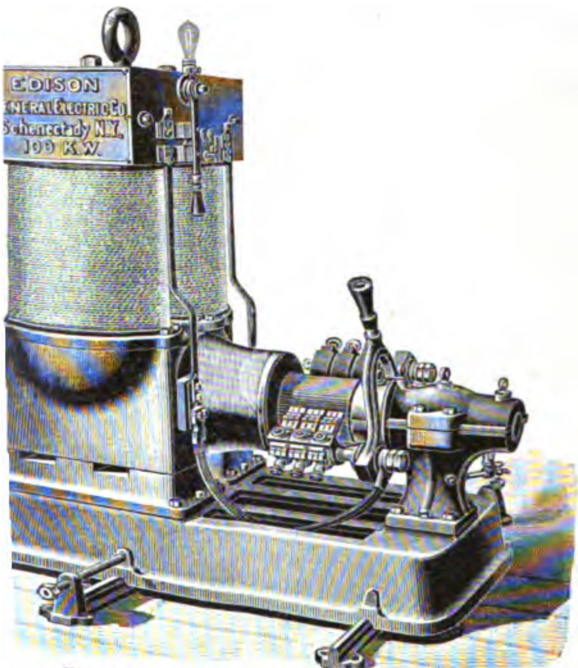
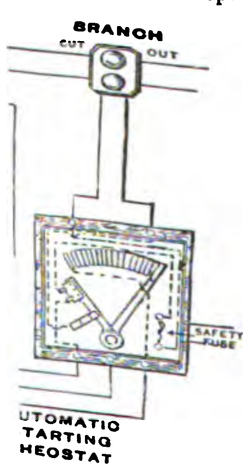


FIG. 38.—Edison motor.

mmutator on the two rings, of which one has an angular
dth of the commutator bar. The two brushes, side by side
d together, so that only one pair is shown in the figure.
Edison dynamo operated as a motor, with merely such



d motor.

changes as are necessary in reversing the direction of rotation of the armature. The differences between it and the incandescent dynamo of a similar size are scarcely discernible, and the windings are practically identical, except in the machines designed for special purposes. Fig. 38 shows the complete machine. The type and general appearance remain the same up to the 150 horse-power motor, corresponding to the larger Edison dynamos. Fig. 39 shows the diagram of connections, both of the motor itself and of the rheostat. The speed of the motors is very nearly that of the corresponding sizes of dynamo of the same voltage, and ranges from 2,100 revolutions per minute in the $\frac{1}{4}$ and $\frac{1}{2}$ horse-power motors, to as low as 360 in the 150 horse-power machine.

Fig. 40 gives a view of the standard *Crocker-Wheeler motor.*
rseshoe type; each pole piece is continuous with its mag-
d exactly to its finished shape. These forgings are fitted
of the motor that forms at once the magnet yoke and the

mechanical advantage secured by this construction is that all the armature wires and bands lie beneath the surface of the armature, and are therefore completely protected from injury.

uotor.

ALTERNATING MOTORS.—*The Tesla Alternating Motor.*—Mr. Nikola Tesla was the first to build a practical motor employing currents of different phase, or what are now termed "polyphasal" currents. One of the types of the Tesla motor, as built by the Westinghouse Co., is shown in perspective in Fig. 44, and with its parts exposed in Fig. 45. It consists of a series of magnets built up of laminated sheet-iron and wound with two sets of coils, the ends of which are connected to the two binding posts shown. These binding posts form the only connection with the regular lighting circuits, with the addition of a single return wire. By the aid of this return wire, two alternating currents are sent through the field of the motor at the same time, the pulsations of the two currents being equal in strength, but the one lagging a quarter phase behind the other in the two sets of field coils, respectively. The effect of this is that a rapidly rotating polarity is given to the field, cor- the currents producing it.

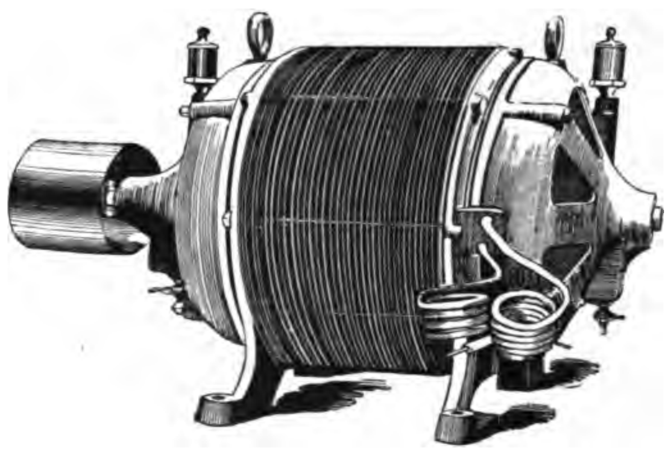
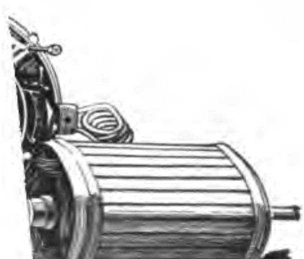


FIG. 44.—Tesla motor.

1e. The reaction between the armature and field is, therefore, similar to that between the primary and secondary of a converter when changes of lamp loads take place in the secondary circuit. The addition of the return wire for the motor circuit can be made easily, so as to adapt existing lighting circuits to motor work. The speed of the motor, as well as its direction of rotation, may be regulated by an ingenious adaptation of the converter principle, an adjustable "choking coil" e use of resistances and switches. The sim- of the motor makes it unlikely to get out of



circuit. *I I* is a mass of laminated iron, in the interior of which the arma-
vith its three coils, B, B^2, B^3, wound on a core of sheet-iron disks. The com-
circuits the armature coils in succession in the proper positions to utilize the
it set up by the currents which are induced in them by the alternations in
The motor has no dead point, and will start from a state of rest and give
ble power. A curious property of the machine is that at a certain speed,
on the rapidity of the alternations in the coil, *C*, a continuous current passes
mutator brush to the other, and it will energize electro-magnets and perform
of direct currents.

Kennedy's Alternating-current Motor is shown in Fig. 50. It consists of y dynamos, with ring or drum armatures and laminated field magnets; both re on the same shaft, their coils being connected together. One of the machines acts as the motor, the other taking the place of the commutator; there are no brushes and no commutator, and, therefore, an entire absence of sparking. The motor requires two currents, one at a quarter of a complete alternation in advance of the other; but it does not require any synchronizing, and it can start with load on from rest. The two currents at different phases are obtained from a transformer, or two line wires with a third for a common return, or from a coil wound on the field of one of the combined machines. Larger machines are made multipolar.

FIG. 50.—Kennedy's motor.

Tesla Motor with Condenser.—In the polyphasal motors above described the difference in phase is obtained by a specially constructed generator. But if the field or energizing circuits of a motor, in which the action is dependent upon the inductive influence upon a rotating armature of independent field magnets exerted successively and not simul-
sly, be both derived from the same source of alternating currents, and a condenser
per capacity be included in one of the same, that approximately the desired difference
se may be obtained between the currents following directly from the source and those
through the condenser. The great size and expense of condensers for this purpose
ould meet the requirements of the ordinary systems of comparatively low potential,
r, are practically prohibitory to their employment in practice. This difficulty has
ercome by Mr. Nikola Tesla, in the apparatus shown in Fig. 51. Here *A B* repre-
poles of an alternating-current motor, of which *C* is the armature, wound with coils,
d upon themselves, as is now the general practice in motors of this kind. The poles,
h alternate with poles, *B*, are wound with coils of coarse wire, *E*, in such direction
ke them of alternate north and south polarity, as indicated in the diagram by *N S*.
se coils are wound long, fine wire coils, *F F*, and in the same direction throughout
oils, *E*. These coils are secondaries in which currents of very high potential are
Mr. Tesla, as a rule, connects all
E, in one series, and all the second-
n another. On the intermediate
re wound fine wire energizing coils,
re connected in series with one an-
also with the series of secondary
he direction of winding being
current impulse induced from
coils, *E*, imparts the same
the poles *B* as that produced
the primary impulse. This
by indicated by the letters *N' S'*.
it formed by the two sets of
is introduced a condenser,
being otherwise closed upon
the free ends of the circuit of
connected to a source of alter-
As the condenser capacity
in any particular motor of
dependent upon the rate of
the potential, or both, its
its cost, as before explained,
within economical limits
the ordinary circuits. It is
giving to the condenser
any desired difference of
the primary and secondary energizing circuits may be obtained.
dying the above principles have also been constructed by Hutin and
ce.

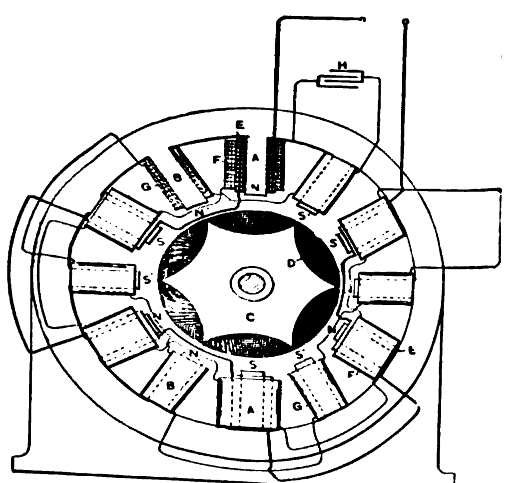
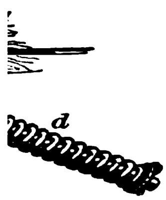
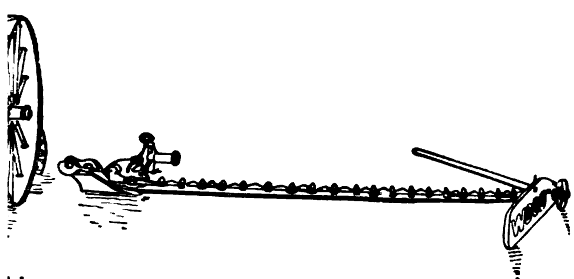


FIG. 51.—Tesla motor.

ort of the operator by the action of the spring,
out swivel ring. The purpose of the device is to
thout sacrificing any of the independent floating

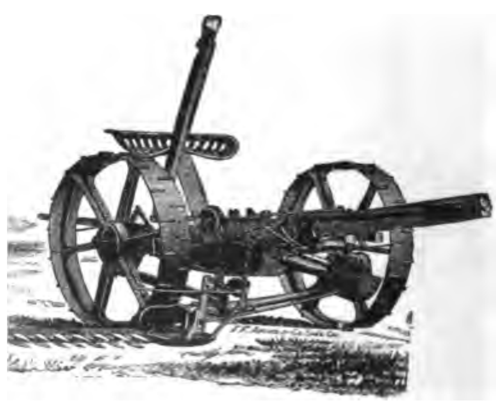


action of the cutting apparatus, which is thus permitted to rest and ride along the variable surface of the ground while mowing, but is instantly controlled, suspended, and lifted by the chain, *b*, when it is desired to pass it over an obstruction, or move the machine forward when not in work. To prevent the lifter lever suddenly flying back by any jolt moving it so as to raise the front end of the rod, *c*, above the lever pivot, a check latch on the quadrant engages a notch in the bearing for the lever pivot as soon as the lever is pushed forward.
Increasing magnitude of hay culture in the United States, and the
have changed mower construction as regards
ten years ago was customarily from 4 to 4½ ft.—



hine. Wide-cut adjustment.

the rule. This change has involved the intro-
lift is a remedy for the difficulty found by the



, Talcott & Co.'s mower.

reased weight and adverse leverage against the
he inner end of the bar to facilitate high lift of
able with long or short finger bars by suitable

t, but one of the two horses drawing the machine must necessarily walk in
o maintain centrality of draft. The scythe is vibrated by a short pitman,
nbination of chain and cog gearing from a chain wheel on the end of the
in turn is revolved forward by both or either of the driving wheels, through
e now universal hub ratchets. The main draft is by the tongue, but any
it may be transferred so as to act upon the cutter frame below, by an
ement of suspended bars and chains, to ease up the cutter bar and its frame
ain axle. The object of this general construction is to attain great width
ction with central draft. The mower may be used right hand or left hand.
—Fig. 7 is the "Buckeye" lawn mower. It is provided with a hinged handle bar, and is self-adapting to the ground surface. Height of cut is determined at pleasure by adjustment of a rolling guide at the rear. The mowing-reel pinions are driven by internally toothed gear wheels, concentric with the ground wheels, in which they are ratcheted, so as to rest when the machine is backed by the operator. The hub of each ground wheel, projecting inward, forms a bearing for the hubs of the gear wheels,

Fig. 8.—Lawn mower.

riving parts laterally, to avoid projections destructive to the bark of trees
front bar also fends them from the blades of the machine. Fig. 8 is a
, with which the lawn may not only be mown, but rolled, and also cleared
, which, as it flies from the mowing reel, is caught in a pan attachment,
wer.

ne: see Engines, Gas.
otton-spinning Machines.

E UTILIZATION OF. Few persons can have seen Niagara Falls with-
e enormous energy which is there continuously expended. No one con-
tional importance and commercial value of supplies of motive power can
lls without some feeling of regret that so much available energy was
ineer it must have occurred that the constancy of the volume of flow,
of levels, the depth of the plunge over the escarpment, the nature of
raphy of the land, the proximity of railways, the access to the Great
ut Niagara as a site for an ideally perfect and unprecedentedly import-
ion.

of lakes or inland seas, which extend half way across the continent,
om a vast territory, store it temporarily, and discharge it through the
e Atlantic. Lakes Superior, Michigan, Huron, and Erie receive the
ment basin of 240,000 square miles, whence it flows through the Niagara
falling in level 326 ft. in a distance of 37½ miles. The average
rio. ated at 265,000 cub. ft. per second If the whole stream between
timated be used to drive hydraulic machinery, more than seven million
ould rendered available.

Fall of Level in the Niagara River.

Niagara River	6 ft.
above falls	50 "
	160 "
below falls	110 "

the falls the river turns at right angles, and flows through a narrow
iagara Falls occupies a flat table-land in the angle formed by the river.
he year of the river levels is small, and is chiefly due to the action of
ariation of level does not exceed 1 ft. in the upper river, or 5 ft. in
greatest authenticated changes of level in the lower river, due to ice
amount to 13½ ft. rise above mean level, and 9 ft. fall below it. The
one and shale, in nearly horizontal strata, and is trustworthy for
tunneling, though timbering is required in the shale, and lining
el of large dimensions.

Power at Niagara.—The early traders erected stream mills in
family caused to be erected factories on the islands in the rapids
ained power from the river. Thirty years ago a much more syste-
e to utilize the falls. A canal was constructed from Port Day, about

better method of utilizing the falls is due to the late Mr. Thomas Evershed, onstruct canals and head races on unoccupied land a mile and more above the the water down vertical turbine-wheel pits into tunnels, discharging into nel passing under the town of Niagara to the lower river. Apart from an

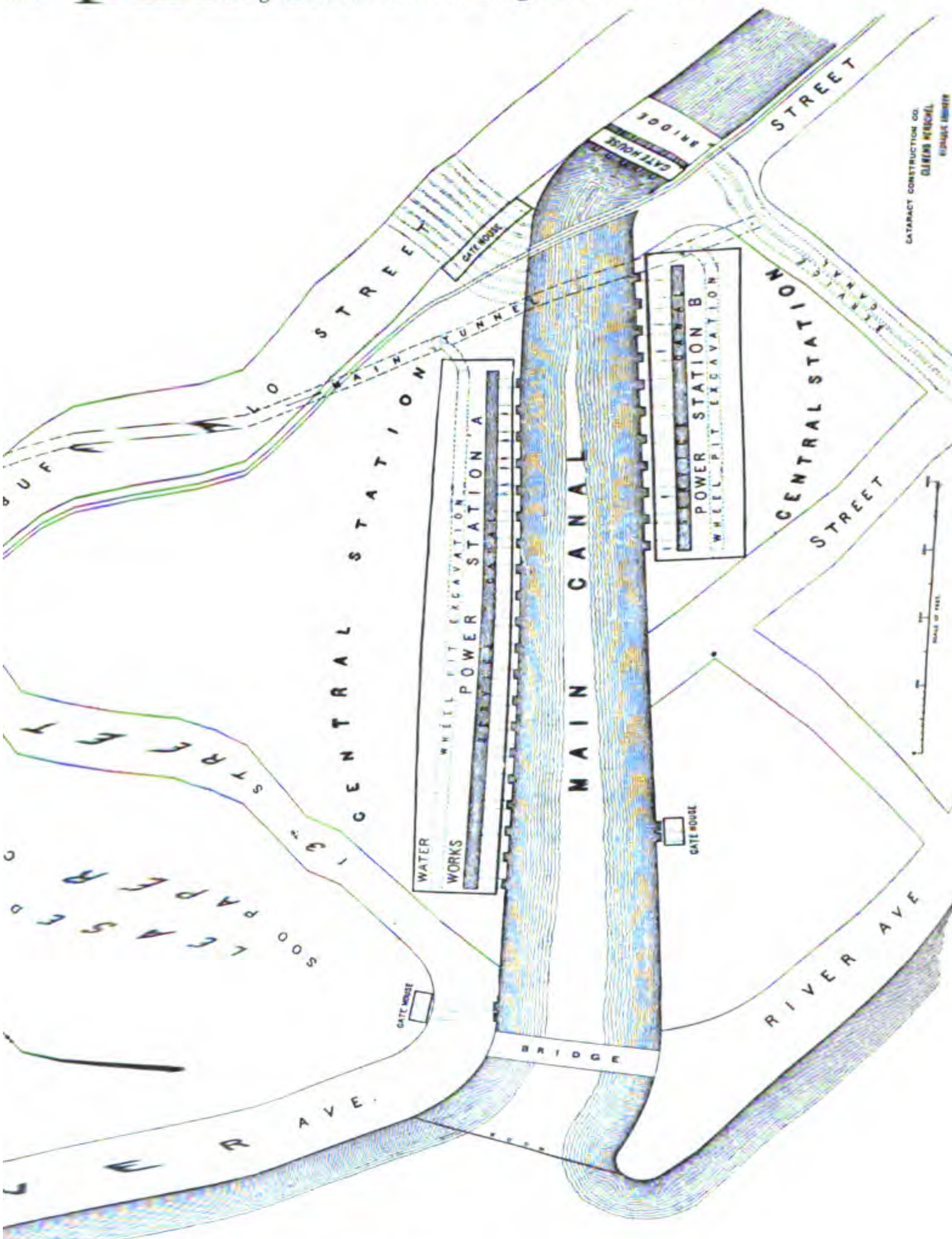


Fig. 2.—Primary power station

of the volume of flow over the falls, this plan avoids any damage its the utilization of a fall of 200 ft. It is essential to the plan of tunnel in the rock, that a very considerable amount of power should the proportionate cost of the tunnel would be excessive.

company is Mr. Edward D. Adams; its vice-presidents are Mr. Francis
nd Mr. Edward A. Wickes, and its secretary and treasurer Mr. William
advise and direct the works they have constituted a board of engineers,
Coleman Sellers, Mr. John Bogart, Mr. Clemens Herschel, Mr. George B.
. Albert H. Porter. Col. Theodore Turrettini, who directed the works for
ive power of the Rhône at Geneva, is associated with them as foreign
er.

1,550 acres of land have been acquired, of which 1,000 acres will be re-
turing purposes, 150 acres for a terminal railway, and about 400 acres for
ict. This latter part is being laid out on a systematic plan. The great
nnel has been commenced, the contract having been given to Messrs.
it. This tunnel will at the outset be 7,000 ft. in length, and 490 sq. ft.
be capable of discharging the tail water of turbines developing 100,000
the present time, 6,700 ft. of heading, and 6,251 ft. of bench have been
nents have also been made for developing initially about 20,000 horse-
ows the position of the tunnel, the intake canal, and the proposed arrange-
facturing quarter. Fig. 2 shows the arrangement proposed for the primary
Fig. 3 shows a turbine wheel pit, with the arrangement of head race and

ower Distribution.—Probably to an engineer considering the conditions
would soon appear that the provision of a tunnel tail race and hydraulic
only half the Niagara problem, and that the least difficult and doubtful
Mr. Evershed and those acting with him considered that nothing more
tilizing Niagara than the adoption of plans already in successful opera-
l States, but on a more gigantic scale. It does not seem to have been at
first that the magnitude of the Niagara scheme was itself a condition ren-
ethods of utilizing water power, if not physically impracticable, at least of
cial success. Nowhere else in the world has water power been utilized
le as in the United States. The towns of Lowell, Lawrence, Holyoke, and
heir very existence as manufacturing centers to water power. At these
ably situated than Niagara, a fall was artificially created by building a
; from the up stream side of the dam, water was supplied to mills by
ischarged it below the dam by other canals. The mill owners constructed
inery, and the water-power companies obtained a return on their expendi-
sed on the quantity of water supplied. Generally, in these towns the
very great, so that no very expensive excavations are required for the
stribution of the water and assessment of the rental presents no special
t for the water supplied varies in different towns; on the average, the
from $14 to $18 per annum per effective horse-power delivered from the
additional charge for interest on capital expended by the mill owner in
, repairs, wages of attendants, etc., would appear to be about $8 per
num. So that the total cost of an effective horse-power to the mill
from $22 to $28 per annum.
n has to be constructed. On the other hand, the tail-race tunnel is a
l that its cost per horse-power utilized diminishes very much as the
er dealt with is greater. The actual section of the tunnel is 490 sq. ft.,
discharge 8,800 cub. ft. per second. Taking the effective fall, after
losses, at 160 ft., and assuming moderately good turbines, this quantity
100,000 effective horse-power. The cost of the tunnel amounts to less
e horse-power. A rock tunnel lined with brick is practically as durable
nd the interest on this sum is but an insignificant item in the charge for
s fully worked. With 8,800 cub. ft. per second, the velocity in the tail-
nly 18 ft. per second if it discharges full bore, or perhaps 25 ft. per
ges as an open canal. Neither of these velocities is too great for a
unnel.

tail-race tunnel imposes, therefore, no difficulty in the way of utiliz-
of a is undertaken on a large scale. It is only when the details of a
d it for distributing so enormous a volume of water to different con-
als and the cost and complexity of a system of secondary tunnels to
d. different consumers, and discharge it into the main tunnel, that a
om practicability of methods in which each consumer takes the water
e his own land, and constructs his own wheel pits and machinery.
er at Niagara will undoubtedly be utilized in this way, especially on
to the main tunnel. In the case of an industry requiring a very
it will be practicable and economical for manufacturers to take the
neel pits, necessarily 180 ft. in depth, and the machinery for utilizing
l is little adapted for smaller factories. It would probably be a long
a sufficient number of large manufacturers could be attracted to
000 horse-power.
greatly economize the capital expenditure to develop the power in one
s by turbines of large size, of uniform type, under common manage-
facilitate the sale of the power if manufacturers could take it in
without the trouble of sinking wheel pits or erecting turbines. Once

Name.	Kind of hydraulic machinery proposed.	Method of distribution proposed.
...on & Siemens Bros. (London.)	Inward-flow pressure turbines of 2,500 horse-power, with horizontal shafts, directly coupled to dynamos in underground galleries.	Continuous-current dynamos of 2,500 horse-power, giving a constant current of 400 amperes, and potential varying up to 4,500 volts. Conductors, insulated cables. Low-tension current obtained by motor transformers.
Pearsall. (London.)	Air directly compressed by pressure due to fall in cylinders, with valves worked by pressure engines. Air pressure, 150 lbs. per sq. in. Pressure water supplied in the same way.	
...ton & Sturgeon. (...ster and Leeds.)	Inward-flow pressure turbines of 3,750 horse-power, with vertical shafts.	Single-acting air compressors delivering at 5½ atmospheres. Compressors geared to turbine shaft. Air main to Buffalo, 10 ft. diameter, decreasing to 7 ft. Electric lighting station at Buffalo worked by compressed air.
Ganz & Co. (Buda Pesth.)	Partial-flow impulse turbines of 5,000 horse-power, with vertical shafts in wheel pits, directly coupled to dynamos placed aboveground. Governor to turbine sluices.	Alternate-current dynamos working at 5,000 horse-power, 336 amperes, 10,000 volts. Overhead conductors on iron supports 50 metres apart. Transformers at Buffalo to reduce potential to 2,000 volts. Separate exciting current dynamos at 200 volts.
...er Wyss & Co. (Zurich.)	Axial flow pressure turbines on vertical shafts in wheel pits. Power varying from 2,500 to 10,000 horse-power.	The Oerlikon Electrical Co. were to have sent designs of dynamos, but were too late to compete.
...ieter & Co. (Winterthur.)	Pressure turbines of 2,000 horse-power on vertical axes. Pressure turbines of 2,500 horse-power on horizontal axes. Pressure turbines of 5,000 horse-power on horizontal axes.	Wire-rope transmission only partially worked out.
...eux & Feray. (Paris.)	Partial-admission Girard turbines, of 34 ft. diameter and 2,500 horse-power, with horizontal axes.	Direct-driven hydraulic pumps, giving pressure water at 710 lbs. per sq. in. A pair of steel distributing mains 24 in. in diameter from each set of 12 pumps, delivering 10,000 horse-power.
...ater Wheel Co. (...Francisco.)	4,000 horse-power and 2,000 horse-power Pelton wheels, with multiple nozzles and governed sluices.	Air compressors, pressure pumps, and dynamos.
...ge Forbes. (...ondon.)	Turbines (not designed).	For Niagara, alternating or continuous dynamos at 2,000 volts. For Buffalo, alternating dynamos at 2,000 volts, the current transformed to 10,000 volts. Bare copper conductors on posts. Synchronizing motors and motor transformers for continuous current at low potential.
...onworks Co. (...alk, Conn.)	Pelton wheels of 5,000 horse-power.	Compound air compressors, delivering at 147 lbs. per sq. in.

...zes were awarded as follows for projects combining the development of power
...ibution: First prize not awarded. One second prize, to the project of Messrs.
...card, Geneva, and Messrs. Cuenod Sautter & Co., Geneva. Four third prizes,
...ts of Mr. A. Hillairet and Mr. Bouvier, Paris; Mr. Victor Popp, Paris, and
... Berlin; Prof. L. Vigreux, and Mr. L. Levy, Paris; the Pelton Water Wheel
...ncisco, Cal., and Norwalk Ironworks Co., South Norwalk, Conn. For pro-
... Hydraulic development of the power, prizes were awarded as follows: First
...project of Messrs. Escher Wyss & Co., Zurich. Two second prizes, to the
...essrs. Ganz & Co., Budapest; Prof. A. Lupton, Leeds, and Mr. J. Sturgeon.
...or the distribution of the power, no prize awarded.
...Z.—Since the invention of machine drills, the question of drilling for the
...rock tunnels has become subordinate to the question of the removal of
...en rock) when rapid driving is required. It is necessary that very little time
...and after firing the blasts, so that the muckers can work the longest possible
... this end, powder must be selected which is free of obnoxious gases, and run-
...rs or cars must be arranged so as to require but one handling of material.
...Flows method in use during construction of Niagara Falls power tunnel.
... was driven in two benches, or, more correctly, one heading and one bench.
... directly from the heading in cars and dumped into cars on lower floor of
... interrupting the working of the lower bench. This is the usual practice
...ing tunnels over 10 ft. in height. Several modes of supporting the runways
...een used, but we know of none so perfectly adapted to saving of time as
... sketch. In timber section the hangers were put in about 8 ft. apart. The
... of 1½ in. × 1 in. Norway iron, steel pointed. Rods were 1 in. in diameter,
...h ends; the bars were of wood, 8 in. × 8 in. 2 in. × 12 in. planks, 24 ft.
...for the bridge or floor, on which a track, fastened together at proper gauge,
...d vantage of this scaffold was that it was easily put up, and that it did not
...een down when blasting the bench. When blasts were made, the planks

has two duplicate spindles placed in a revolving drum, which is
.lways to have one spindle above the other. This arrangement
remain at rest, and allows the work to be removed and replaced,
are facing the work on the lower spindle.
ıde of bar steel ground to shape and tempered, are held in an
a cam motion and change gears. Three cutters are used, shaped

st thread, the second relieves or rounds the corner, and the third
ı cutter can be shaped to do *all* these operations, this arrange-
me of grinding and resharpening. It will be seen that in this
› the
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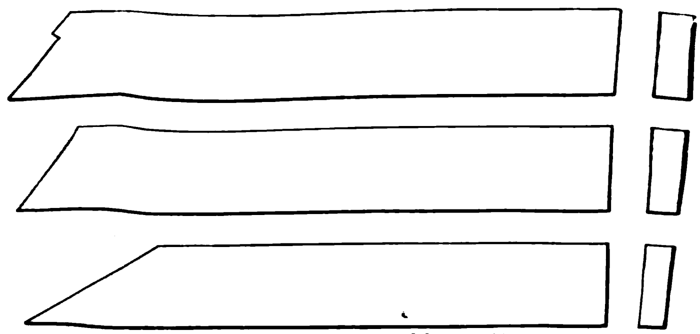

Fig. 2.—Nut-facing machine cutters.

The nut-facing machine, Fig. 3, may be used in place of
ıachine. The tools for facing can be made 12 in. long, and the

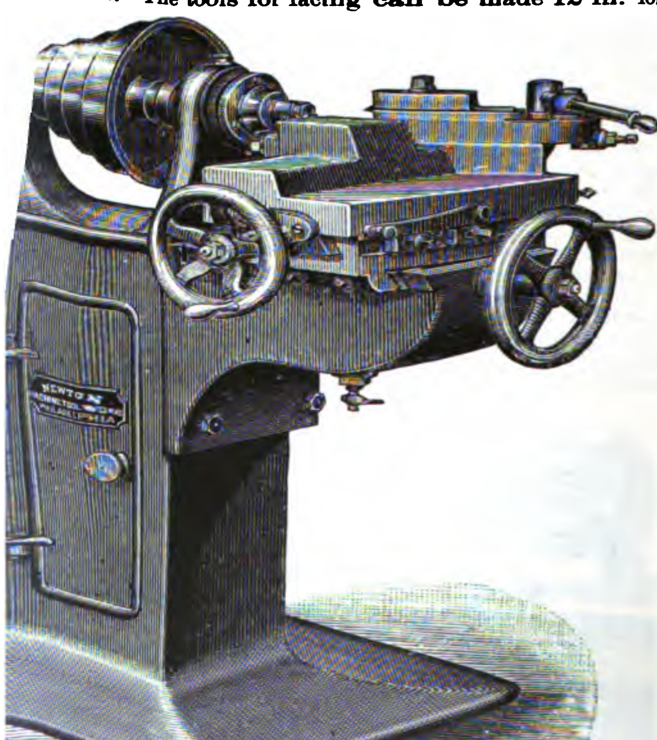

Fig. 3.—Nut-facing machine.

milled lengthwise on their faces. An important feature of
.ing the burr from the thread. A small tool is held in the

r arm with a spring plunger of the size and shape of the blank to be tapped, ing formed in cross section to corespond with the blank to be tapped, and the upper end of the tap, *I*, supported at its lower end by the chuck, *C*. of the point where the conduit joins the chamber is a plunger adapted to vard. The actuating mechanism is operated by rod, *h*, the movement of l by the cam groove, D^2, placed on the wheel, *D*, which is operated through shaft, *B*. The blanks from the conduit fall in a vertical position into the e plunger advances, each blank is carried forward until the lower edge rojection formed on the bottom of the chamber. The blank is thus turned, on of the plunger carries it forward to a point immediately above the tap. he spring plunger. Provision is made to insure that the blank will come over the tap, and for holding it at the proper point to be fed under the plunger. At the proper time, the full force of the spring plunger is e blank, which is held upon the tap until it is formally engaged. The rries the tap, is hollow throughout its length, and is secured in a beveled f which turns in a suitable bearing in the main frame. This gear is gear. as shown in Fig. 2. orted in a vertical position, with the screw-threaded portion upward, the being of such a size as to permit the nut to drop off when released by sm. The tap is revolved by the chuck, and means are provided for auto-

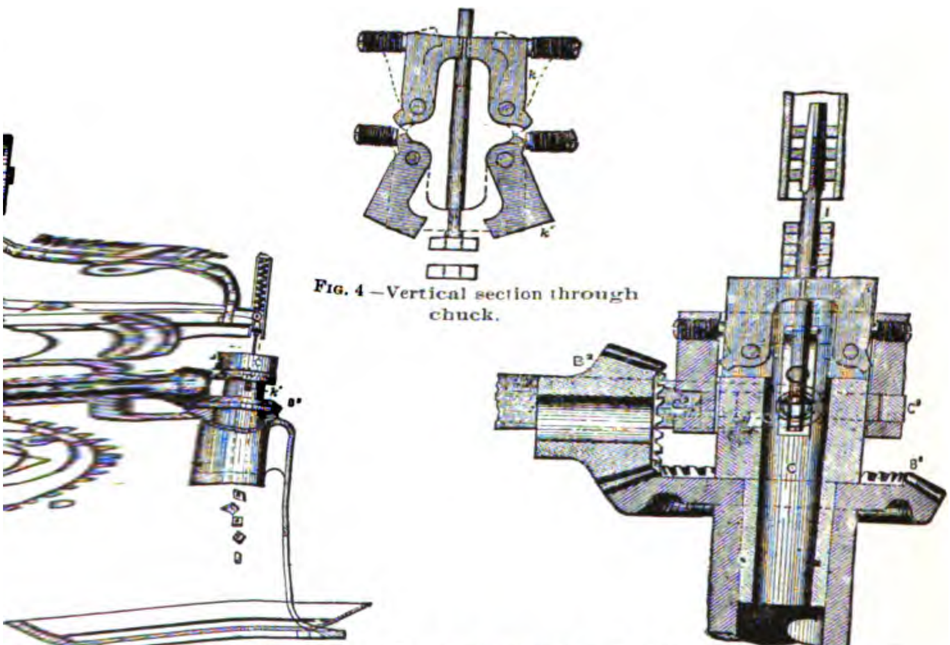

FIG. 4.—Vertical section through chuck.

sectional elevation. FIG. 3.—Section through chucks and operating mechanism.

FIGS. 2-4.—Automatic nut-tapping machine.

the tap at one point when it is engaged at another, thereby permitting the by their weight from one end of the tap without any intermission op machine, and without changing the longitudinal position of the tap. na chuck, shown in vertical section in Fig. 3, consists of a sleeve pro- e ch its length with two pairs of jaws, which are adapted to embrace s in and are placed preferably at right angles to each other, although its, the same vertical plane, as shown in Fig. 4. The jaws, *k k*, are in opening in the sleeve, and are provided at the bottom with a cam l the supporting sleeve is an outer collar provided in its periphery g adjustable projections provided to bear against the outer surfaces of adapted to revolve with the sleeve, and is also capable of longitudi- leeve. As it is moved longitudinally in either direction, its projec- cam projections on the respective jaws, causing them to separate, he projections being so placed on the collar that when one pair of other pair is closed tightly against the tap. on the shank of the tap, for a time sufficient to tap a sufficient d lower pair of jaws are closed on the shank, and the other pair e

Jordan's Reducer, sometimes used in crushing gold ores for amalgamation in connection with Jordan's amalgamator (see GOLD MILLS), is a revolving pan, set at an angle, and carrying three massive balls of white iron, which work in a suitably shaped bed, also of white iron, round the greatest circumference of the pan. The ore and water are fed automatically into the bed of the pan, and by the rotary motion of the latter, are conveyed under the rapidly revolving balls, whereby the comminution of the ore is effected. The inner half of the floor of the pan rises as a shallow dome surrounding the central shafts, and is fitted with movable frames carrying wire screens of any required mesh. The feeds of ore and water, and the inclination of the screens, are so adjusted that, as the ore is reduced to a sufficient degree of fineness, it is washed over the screens and passed away into a launder for conveyance to the amalgamator. It is claimed that this machine has reduced 20 tons of ore in 24 hours, so as to pass an 80-mesh screen.

The Huntington Mill (Fig. 14) consists of a spindle, *G*, carrying a circular frame, *B*, at its top, from which are suspended four steel rollers, *E*, which are rotated against a ring, forming the base of a mortar or pan. The ore and water being fed into the mill at the hopper, *A*, the rotating rollers and scrapers throw the ore against the ring die, where it is crushed to any desired fineness by the centrifugal force of the rollers as they pass over it. The water and pulverized ore are thrown against and through the screens when fine enough. The rollers are suspended, leaving a space of 1 in. between them and the bottom of the mill, thus allowing them to pass freely over the quicksilver and amalgam, without grinding it or throwing it from the mill, while it agitates it sufficiently to insure amalgamation. This mill is used for crushing and amalgamating gold ores, with excellent results. It is also employed for fine-crushing in dressing works, but its use for that purpose is not to be recommended, as it slimes the ore excessively. The manufacturers furnish the following data :

Size.	Weight.	Revolutions.	Capacity.	Power.
4 ft. diameter............	7,000 lbs.	90	12 tons.	4 H. P.
[illegible] ft. " "............	11,000 "	70	20 "	6 H. P.
[illegible] ft. "	20,000 "	55	30 "	8 H. P.

The Griffen Mill consists of a shallow cast-iron ring or mortar, which is surmounted by a [tall] sheet-iron cone, with an opening at the apex, through which a vertical shaft works. [T]his shaft, which is driven by a horizontal pulley, has a universal-joint at its upper end—*i.e.*, [ju]st below the driving pulley ; while at its lower end is rigidly fixed a heavy cast-iron roller. [T]he shaft and roller being free to move by means of the universal-joint, the roller is [th]rown against the side of the mortar or crushing ring by centrifugal force, and the rock or [or]e, which is fed in through an opening in the side of the case, is thus pulverized. The [cr]ushing roll swings several inches above the bottom of the mortar, but upon its lower side [th]ere is a plow which stirs up the ore in the bottom, and throws it against the ring die, [w]here it may be acted upon by the roller. The crushed ore is discharged through screens in [th]e case just above the ring die. A fan attached to the shaft above the roll causes the air to [dr]aw strongly into the mill, and prevents the escape of dust. This mill is extensively used [fo]r fine grinding, such as pulverizing phosphate rock, but is not adapted to work where the [fo]rmation of an undue proportion of slimes is to be avoided. It is stated that it will grind [t]ons of South Carolina phosphate rock per hour, so that 75 per cent. will pass a 75-mesh [scr]een.

The Narod Pulverizer, similar to the Griffen mill, consists of a shallow, heavy cast-[iro]n mortar or pan, surmounted by a conical sheet-iron case, in which are revolved three [iro]n rolls, carried loosely at the end of vertical shafts. The shafts are fixed in an iron cast-[ing] at the top of the machine, having, individually, a radial play in order to allow for [cent]rifugal motion, and the whole is rotated by a horizontal pulley at the top of the ma[chin]e. The rollers, being loose on the shafts, are free to turn. The ore is fed into the machine [at th]e side, just above the rollers, and is crushed against the side of the mortar. Each shaft [is co]vered by a sleeve, fixed to the roller, and extending to the top of the shaft. On each [sleev]e, just above the roller, are two spiral fans which, according to the makers, take up the [mate]rial after preliminary grinding, and keep it in self-frictional agitation until rendered [fine e]nough to discharge through screen in the base of the machine. The sleeves on the verti[cal sh]aft serve as oil chambers for the rolls, and the main or central shaft, which is hollow, [serve]s as oil chamber for the main journal. The main shaft is driven at 140 revolutions per [minu]te. This machine has been used for pulverizing phosphate rock, etc., but, like the [Griffe]n mill, does not seem to be adapted for anything but fine grinding.

[A]ustin's *Rotary Pulverizer* consists of a cast-iron cylinder, or barrel, hung horizontally [on] two hollow trunnions. Within the barrel is a ring, of somewhat smaller diameter than [the b]arrel itself, composed of chilled-steel bars, placed longitudinally and a small distance [apart], like grate bars. Within this annular grate-bar ring are two heavy cast-iron rolls, [whic]h are nearly as long as the cylinder itself, lying loosely. The cylinder is turned slowly [on] the trunnions. Ore is fed into a hopper at one side of the cylinder, and passes into the [latte]r by means of a tube projecting through one of the hollow trunnions. The ore falls onto [and u]nder the rollers, and is crushed between them and the grate-bar ring. The crushed ore

not only for prolonging the life of the shells, but for securing the maximum efficiency in crushing, and this feeder has given excellent results.

ORE-DRESSING MACHINERY. DRESSING WORKS. (See ORE-CRUSHING MACHINERY).—Ore dressing is the art of separating the mineral in ore from the worthless rock or gangue, with which it is intermingled, the mineral, thus concentrated, being subsequently treated by the proper metallurgical process. In dressing ores mechanically, there is always a loss in values, varying from 10 per cent. to 50 per cent., or even more, and it is not customary to subject to this form of preparation ores which can be directly treated economically by any of the ordinary metallurgical processes. Mechanical dressing is, consequently, only resorted to when the cost of the operation and the loss in values is more than balanced by the saving in freight and in the cost of the subsequent treatment of the ore, gained by the elimination of the worthless gangue.

The method of mechanical ore dressing, in general, consists in crushing the ore to sufficient degree of fineness to free the particles of valuable mineral from the gangue, and afterward effecting a separation between the two by virtue of the difference in specific gravities. Two classes of crushing machinery are commonly used in every dressing works, viz.: coarse-crushing and fine-crushing. The former, of which the well-known Blake crusher is a type, takes the coarse lumps of ore as they come from the mine, and breaks them to a convenient size to be received by the fine-crushing machine, which may be a set of Cornish rolls. In most mills there are two sets of rolls in each crushing system, the final comminution being done in the second, which are set closer together than the first. Between each crushing machine and the next in series there should be a screen, over which the crushed ore is passed to remove the particles already crushed finely enough, thus relieving the following machines and preventing this ore from being crushed finer than is necessary, an important point, as the fine ore becomes slime, when mixed with water, which will probably give rise to increased loss in the dressing. Similarly, the ore is frequently dumped over a grizzly (a coarse screen composed of parallel steel bars), before being fed to the first crusher. The crushed ore coming from the finishing rolls is passed over a screen, the mesh of which constitutes the standard of crushing of the mill. That which will not pass through this screen is returned to the rolls; that which passes is sized in preparation for the washing machines. The sizing is done either by screens or hydraulic separators, but generally both systems are used in the same mill. With the former, the operation being technically known as "sizing," the particles of ore are divided into classes of equal size; in a hydraulic separator the particles of ore settle against an upward current of water, and are thus classified into equal falling grains, the operation being technically known as "sorting." The usual practice in dressing works is to size by screens particles down to about 1 mm. in diameter. The finer particles are sorted. At Lake Superior, where there is a great difference in the specific gravities of the minerals to be separated—native copper and the various siliceous minerals which constitute the gangue—hydraulic classifiers alone are used. Screens, only, may be used in mills doing very coarse work, but never in a well-designed mill intended for fine and close work.

The sized and sorted ore goes from the screens and separators to the washing machines, by which the heavy particles of mineral are separated from the lighter particles of gangue, by virtue of the difference in specific gravities. Washing machines may be divided into two general classes, viz.: sand washing, represented by the various kinds of jigs; and slime washing, of which the various slime tables and buddles are types. The sized ore of which the particles are between 16 mm. and 4 mm. in diameter, is commonly designated as pea; between mm. and 1 mm., as sand; and finer than 1 mm., as meal. The pea and sand sizes are washed in jigs, the material from each sizing screen being conducted to a jig properly designed and adjusted for that size. The meal sizes, from the hydraulic separator, are washed on the me machines; the coarsest meal is worked on jigs, varying from the coarser jigs only details of design, speed, etc., while the finer meal is conducted to other machines apted to the size and character of the ore. With the washing machines the operation dressing is completed, and the concentrates are ready to go to the smelting works, or where, for further treatment.

The cost of dressing varies, of course, with the capacity of the mill, the character of the and the quality of the work done. The following are a few instances of the best American practice: At the Atlantic mill, Lake Superior, siliceous copper rock containing from per cent. to 1·00 per cent. native copper has been dressed (1886) at a cost as low as 26·5 per ton, about 70 per cent. of the mineral being saved. The cost may be subed, assuming the same percentages as in the previous year, about as follows: Labor, r cent.; fuel, 47·5 per cent.; supplies, etc., 17·5 per cent. The cost of dressing in this in 1890 was 27·78 cents per ton. At the mill of the St. Joseph Lead Co., at Bonne, Mo., ore was dressed in 1887, according to Prof. H. S. Monroe (Trans. Am. Inst. Min. Engrs. vol. xvii. 659), at a cost of 36·4 cents per ton, divided as follows: Labor, 13·4: repairs, 10 cents; supplies, 3·5 cents; coal, 9·5 cents. At this mill all the water has to be pumped to the crusher floor; and all the tailings are carried off in cars, disntages under which the Atlantic does not labor, so that in making a comparison between wo, it is only fair to deduct 10 cents per ton, in Professor Monroe's opinion, from t. Joseph figures. The St. Joseph ore is galena with a magnesian limestone gangue, ing from 7·5 per cent. to 8 per cent. lead. The capacity of the mill is 800 tons per The loss in tailings amounted to 27·4 per cent. of the mineral. At the Hecla Conted Mining Co.'s mill at Glendale, Mont., ore assaying 7 per cent. lead and 15 oz. per ton, was dressed, in 1890, at a cost of 41·47 cents per ton, 55 per cent. of the

SIZING SCREENS.—Sizing screens are a very important part of a concentrating mill, as the success of the subsequent separation of the various constituents of the ore to be treated by the hydraulic machines depends upon the proper sizing of the particles. The ordinary sizing screen or trommel consists of a series of spiders, keyed to a shaft, over which is stretched wire cloth or sheets of punched steel or iron plate. The number of trommels and the mesh of the screens on them is regulated to suit the character of the ore treated and the degree of separation desired. The general arrangement of the trommels used in concentrating mills is shown in Fig. 2. Each trommel is geared to the one next to it, so that the whole line may

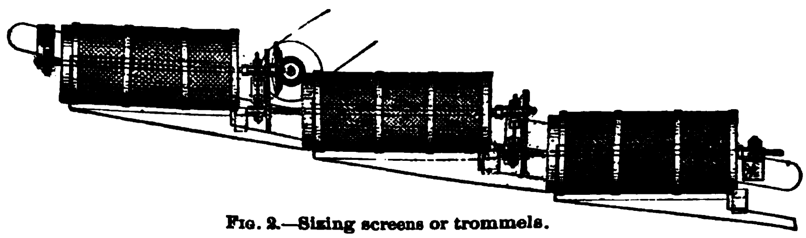

FIG. 2.—Sizing screens or trommels.

be driven from one point. The fine material from one screen passes to the next finer screen, and so on to the required number. The material remaining on each screen, and afterward discharged to the proper jig, is thus sized—*i.e.*, it has passed through the perforation of the preceding screen and will not pass through the perforations of the one retaining it. In dressing works the ore is invariably screened wet. The water for this purpose is sometimes fed through the shaft of the trommel, which is in this case made hollow, but usually from a perforated pipe hung above the trommel. Trommels are sometimes made of conical form, the axis being horizontal, and occasionally both cylindrical and conical screens are made with two sizes of wire cloth upon the same frame, making, in effect, a compound trommel. Concentric trommels, which consist of drums of different mesh, one within another, are never used now, the difficulty of repairing them making them highly objectionable in a mill. It is not usual in well-designed dressing works to use screens finer than 20-mesh, as the material which will pass that size is better prepared for the slime jigs and tables by hydraulic separators, and the finer screens wear out too fast, increasing expenses for repairs, and causing undue loss of time in patching or recovering them.

HYDRAULIC SEPARATORS.—Hydraulic separators are machines for classifying the fine material to be concentrated into groups of particles which, under like conditions, fall through the water together, the material thus being prepared for the jigs or other slime-washing machines. The hydraulic classifiers in general use are, with unimportant modifications, forms of the old German *Spitzlutte* or *Spitzkasten*, in which the particles of ore settle in pointed boxes against an upward current of clean water. They are regulated according to the work to be done by varying the velocity of the stream of ore and water passing through them, and the strength of the upward current of water.

The Calumet or Richards-Coggin separator (Fig. 3), which is generally used in the Lake Superior dressing works, consists of four or five boxes, *D*, *D*, etc., or depressions in the bottom of a continuous trough. The water and sand enter at *m* and undergo successive washings in each box until the fine sand overflows at *n*. The operation in each of the boxes is as follows: The heaviest sand at once finds its way to the bottom of the box; the wash-water is brought in through the pipe, *a*, in greater quantity than is sufficient to supply the spigot, *E*. No sand, therefore, can find its way out through *E* that has not weight enough to stem this water stream. This excess of water also acts by keeping the whole bottom of the box in a boil and turmoil, thus ever pushing up the lighter sands and allowing the heavier to keep near the bottom. The shield, *c*, prevents the stream from rising straight up, thereby confining the turmoil to the bottom of the box.

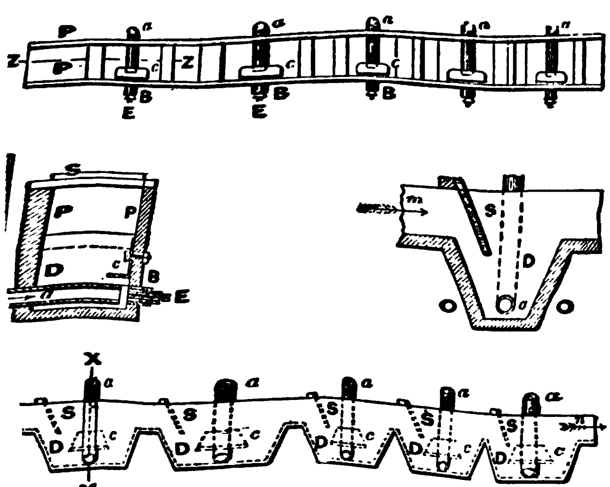

FIG. 3.—Calumet separator.

3.—This is the general name for the concentrating machine universally employed for

belt, extra supporting rollers on the shaking frame are necessary. The surface of the corrugated belt is given a slightly greater inclination, a fall of from 3 in. to 5 in. in 12 ft. being commonly used, instead of 3 in. to 4 in., as in the case of the plain belt. The water distributor consists of two rows of water jets, 1¾ in. apart, the back ones alternating with the front ones, the distance between the back and front rows being 2¾ in. The distributor is placed from 1 in. to 2 in. higher up towards the head of the belt than in the old machines, and is also raised somewhat higher above the belt, so as to give a drop of about 1¾ in. from the spouts to the belt surface. More water is required than with the old belts. The revolutions of the crank shaft vary from 194 to 210 per minute, and the forward motion of the belt from 28 ft. to 33 ft. per minute, according to the character of the ore treated. The capacity of this machine is considerably greater than that of the ordinary Frue vanner, and it can be used for the treatment of coarser slimes. Indeed, these belts have given excellent results at some places on material that is usually washed on meal jigs.

The Embrey Concentrator is very similar to the Frue vanner in construction and operation, but the belt is given an end shake instead of a side shake.

The Triumph Table is also a belt machine, resembling the Frue vanner and Embrey concentrator, and, like the latter, the belt has an end shake.

The Lührig Vanner is an end-shake belt machine which is very similar to the Frue vanner in construction, and works upon the same principle.

The Garnier Concentrator is a belt machine, in which the belt is given a peculiar panning

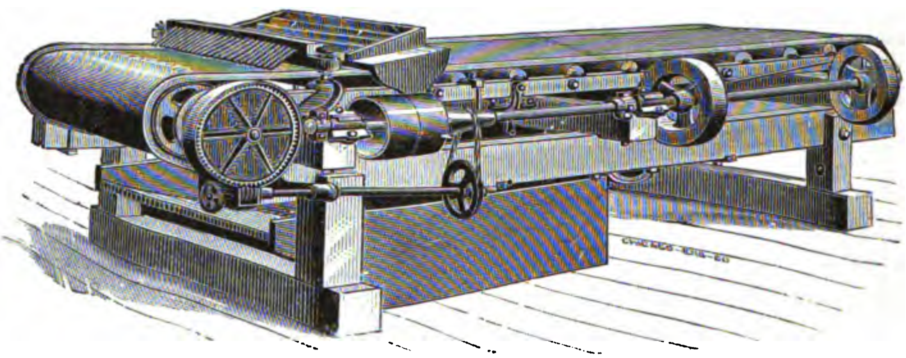

FIG. 6.—Frue vanner.

motion. The belt frame is supported at the rear end on a sliding bearing, and at the front by a vertical eccentric shaft. By means of the eccentric a circular movement is imparted to the forward part of the belt, which becomes approximately a simple back and forth throw at the other end. The belt has a continuous forward movement, as in other machines of this class, and is fed and adjusted in similar manner.

The Woodbury Concentrator is similar to the Frue vanner, but instead of the single smooth belt, thirteen narrow parallel belts are used. The pulp being equally divided be- ;ween these belts, which prevent it from running to one side of the machine or the other, it s claimed that a thicker bed of pulp can be worked, and that the machine has increased apacity in consequence. A revolving feed-bowl distributes to each belt its exact proportion f sand and water. The rims of the belts are corrugated to prevent cracking as they stretch ı passing over the end rollers. The capacity of this machine is claimed to be from 12 to 15 ns per 24 hours. Several of them have been introduced recently, but no actual working sults have been published.

The Golden Gate Concentrator consists of a tray about 11 ft. in length, resting upon pports, upon which it has a longitudinally reciprocating movement. This reciprocating vement varies in speed in such manner as to cause the pulp, fed upon the tray at one end, travel slowly over its surface toward the other end, and the pulp is, by the shaking ion, kept in a loose condition, so that the mineral may settle out of the gangue upon the ace of the tray. The tray proper consists of two distinct parts, forming, however, one tinuous surface. One part, being designed for the settling of the mineral, is horizontal, has hardly any perceptible current of water, thus allowing the fine mineral to settle out he water and reach the bottom of the tray; the other part has an adjustable inclination ards from its junction with the horizontal part, and over this part the current of wash- er flows, which washes away the gangue from the mineral. At the junction of the hori- al with the inclined part of the tray, and extending across its width, is a protecting e, set somewhat above its surface and parallel thereto. Above the protecting plate is an aust tube extending across the tray, and connected with two settling chambers, one on er side of the tray, within which a vacuum, sufficient to sustain a column of 4 in. ; in. of water, is constantly maintained by an exhaust fan. Just above the protecting e, and connected with channels formed in the body of the exhaust tube, are exhaust iths, into which the gangue and water are drawn by the vacuum maintained, being then harged over each side of the machine into the settling chambers, and thence into the

s over the other half, being controlled by the division piece, *L*. The sand and water ng on one side of distributor, *B*, runs through its perforated bottom, and are distributed ually over one-half of the stationary head, *C*, and run on the rotating table, *D*, into the cular launder, *N*, then through the waste pipes, *O O*; the ores remain on the upper part table, *D*, and after concentration being shielded from the action of clear water by the ne-shaped head, *C*. The proper grades of ores are, through the action of clear water, washed about half way down the rotating table, *D*. They then come in contact with the diagonal perforated pipe, *E*, and are re-washed by a succession of small jets from perforations of small pipe. The ore passing between the jets is carried around on the rotating table, *D*, until it comes in contact with a jet of water from pipe, *F*, and conducting board, *G*. The jet, *F*, conducts the ore into hutch, *H*, through pipe, *I*.

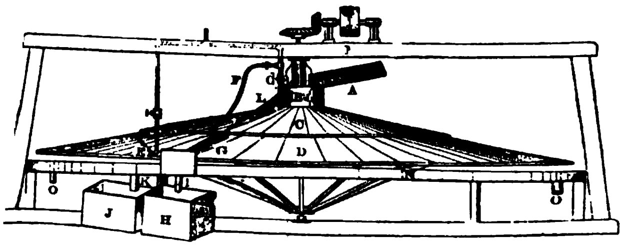

FIG. 8.—Evans table.

he middle or second grade ore is washed off table, *D*, by the perforated pipe, *E*, and is eposited in hutch, *J*, through pipe, *K*, to be re-washed. The head, *C*, is suspended from ame, *M*, so that it can be readily adjusted relatively to the table as it may be required. he arms and segments should be made of hard pine, about half seasoned. The sheeting r surface should be soft pine, and must be green lumber and perfectly clear. The surface f table must be true and uniform, and the width of the boards should not exceed 5 in. he boards are joined by tongue and grooves. The speed of machine is one revolution in 0 seconds. Pitch or incline of table, 1¼ in. to 1 ft. Pitch of head, 1¾ in. to 1 ft. The apacity of the machine is 25 to 30 tons per day of 24 hours.

The Linkenbach Buddle is a stationary, continuous-working, outward-flow table, designed y C. Linkenbach. The table itself is fixed, but both the supply and receiving launders evolve, the advantages thus gained being cheaper construction and the possibility of sing very large tables, requiring small motive force. The principle of the slime washing n this table is the same as with the rotary round table. The slimes are delivered upon a istributing apron at the center, and are discharged at each revolution of the axle, preading out over the table. The axle carries the perforated wash-water pipes, which xtend out over the table, and at each revolution wash the pulp covering the surface of the latter. The headings and tailings are discharged into a circular launder, around the table, which revolves at the same rate as the wash-water pipes. The tables are made of thin iron plates, supported by radial arms, covered with a layer of cement about 3 in. thick. The capacity of a single table, 26 ft. in diameter, is said to be about 15 tons of fine meal and pulp per 24 hours. To economize space, and further cheapen the cost of construction, triple tables re sometimes used, the three eing placed one above the ther, and the feed-water ipes being carried on the ame axis.

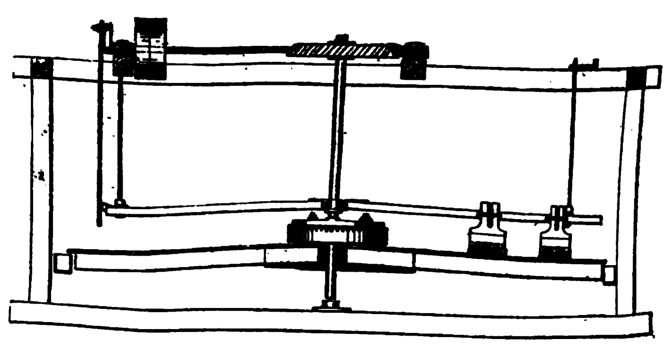
FIG. 9.—Collom buddle.

The Collom Buddle (Fig. is a convex, circular revolving table, over one-half of which, and parallel with its surface, e fixed six light arms, from each of which are suspended two or three small brooms, lightly eeping the surface of the table. The pulp is fed at the center of the table, and as it reads out the coarser particles are stirred repeatedly from their positions and caused to roll itward, or toward the tail end of the table.

IRON-ORE DRESSING MACHINERY.—In this country much money, labor, and thought have en devoted to the enrichment of iron ores by roasting to drive off sulphur and carbonic id, or make the ore more friable, and by washing and screening to remove the clay and nd from earthy ores. Iron ores being so different in character from lead, zinc, and copper es, their value per ton being so much less, and many varieties being magnetic, a property hich is made available in the separation of the mineral from the gangue, iron-ore dressing orks, and the machinery used in them, is quite different from that employed for other ores. arthy, clayey ores are cleaned in many districts by crude machines of large capacity, such log-washers, which suffice to make a fairly good separation of the mineral and gangue, e difference in specific gravity being so great. Rough jigs are used in many places, and

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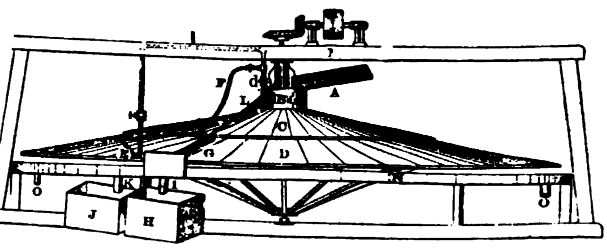

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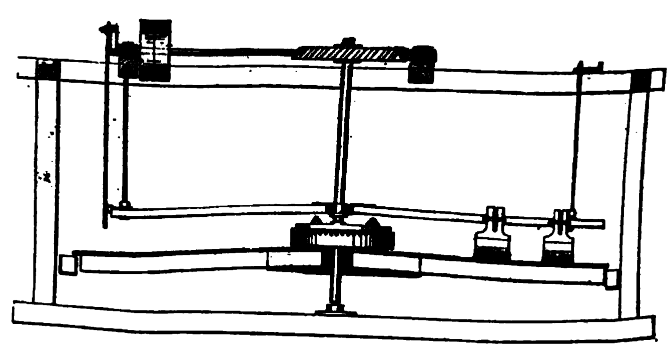

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ds and heavy oak bottom and sides. The box is usually
2 ft. deep, having two heavy pieces of timber (see Fig.
d fitted with gudgeons to revolve in suitable bearings in
se shafts, or "logs," are provided with a series of blades,
elically, in such manner that the logs, which are turned in
e screws. The main box is set at a small angle from the
, its lowest end, while a stream of water enters at the upper
re, and move it, gradually, to the upper end of the box,
, through a proper opening, the current of water having
ess gangue. The water and tailings leave the box at the
n the machine is inclined, and the quantity of water used,
he ore treated. The manufacturers of these machines give
mount of water required for a 25-ft. double-log washer, 35
city, 50 to 75 tons of ore per day ; power required, 12 to 15

of a circular sieve, suspended from one end of a lever in a
and 4 ft. 8 in. deep (inside measurement), being moved up
he opposite end of the lever. The concentrates pass through
tub ; the tails pass out by means of an annular opening around
rrangement of this jig, as used at the works of the Chateaugay
ountain, N. Y., is shown in Fig. 11. The spider is made in one

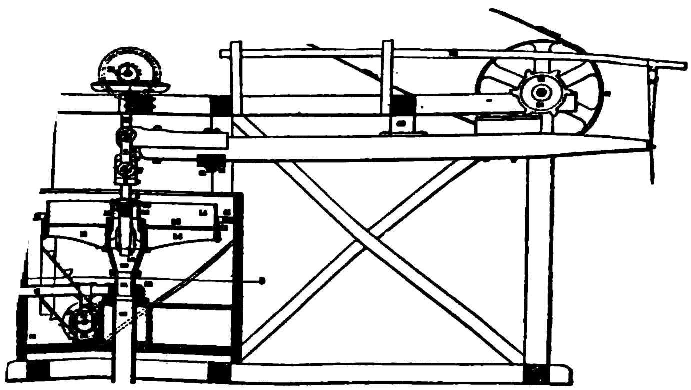


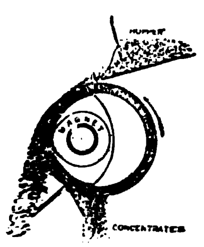
FIG. 11.—Conkling jig.

h a taper bore to receive the jig shaft, which is keyed into it. It is also
ndards from the flange, which may be moved by the upper and lower
oop, 12 in. high, is bent around the spider, and fastened by the holding-
re riveted to the rim, pass through the holes in the end of the arms, and
ith nuts. The screen plates rest on the arms of the spider, and are held
passing under the arms and through the holes in the screens. The
in. thick, made of cast-iron, in segments of $\frac{1}{8}$ of a circle ; the holes are
on top, and $\frac{7}{16}$ in. below.
lted to the spider is the cone (20); under that is the water sleeve (21), which
n in the water box (22). All the water which is to be used in jigging
ese two boxes, and flowing out through the annular openings, keeps the
n grit. The water, under pressure of 8 ft. head, enters through the 8-in.
d with a valve (42) to regulate the quantity.
piece (7) is kept in place by the upper and lower collars, which are provided
The links (5) connect the jig with the lever beam. The jig shaft passes up
izontal bevel-gear wheel (1) by which it is rotated ; the shaft moves freely
ut it is provided with splines in which fit keys attached to the gear wheel.
riven by belt from the rear driving shaft (33). The pulleys to transmit the
are conical, reversed in order to change the speed. The cam wheel (26) is
6 cams, and is keyed to the shaft, which is driven by a belt 8 in. wide.
he 36-in. driving pulley (27). The cam wheel makes 43 revolutions per
g about 260 jars per minute to the jig. The lever beam is set to move
d down about $\frac{3}{4}$ in., giving a slow up and a quick down motion. The jig
revolutions per minute. The practice in dressing iron ores at Lyon Mountain,
by Mr. F. S. Ruttman, Trans. Am. Inst. Mining Engrs., vol. xvi. 609, is as
e crushed ore is brought from the hoppers to the jigs by chutes provided with
lower end, just above the screen plates. The screens are first covered closely
of heavy ore about the size of hickory-nuts ; the crushed ore is then spread over
is level with the collar of the spider, about $2\frac{1}{2}$ in. to 3 in. deep. The spring
ected with the lever beam by the strap, the water turned on, and the jig started.

ced that the magnet occupies a sector of the drum, the proportions being such that, mately, one-third of the periphery of the drum is within the influence of the magnetic hile the upper two-thirds is outside of the field and removed from the magnetic influ- The magnet is so constructed as to present a series of poles of alternately opposite y near the inner surface of the drum. In accordance with the well-known phenomena gnetic attraction, which in the case of powerful magnets is exerted at a considerable e from the magnetic poles, any magnetizable matter brought near the outer surface drum, within the arc covered by the magnet, will be powerfully attracted and drawn rm contact with the outer surface of the drum. These drums are composed of a non- ic and neutral material, such as wood, paper, etc., and they turn in the direction indi- by the arrows near the top of the drums. Just below the feed hopper, an apron of l metal, *3*, is arranged, curving downward and forward in the direction of the rotation drum, its lower portion describing a short arc concentric to the surface of the drum. erves as a chute to direct the stream of ore falling from the feed hopper within the nce of the first two or three poles of the magnet. A similar but somewhat shorter , *4*, is arranged in like relation to the second drum and magnet, *b*.

operation the magnets are excited, the drums revolved in the direction indicated, and r current established through the machine in a direction opposite to that of the drums. re passing down the chute under the first drum, the magnetizable portions are drawn contact with the drum, and take on the forward movement of the latter. When the ore es the limit of the arc covered by the magnetic field it is no longer attracted, and takes tangential movement, which carries it away from the drum. It has now, however, d the edge of the second apron, and, on leaving the first drum, comes within the influ- of the magnet of the second drum, where similar operations are repeated, a portion g finally discharged as concentrate at *c*. The function of the second drum and magnet g to differentiate the product from the first drum into two portions, which may be con- ently designated as middlings, discharged at *m*, and concentrates, discharged at *c*. The working capacity of a machine having drums of 24 in. diameter and 24 in. working is said to be from 15 to 20 tons per hour of ore granulated to pass 16 to 20-mesh screens. power required is from 1 to 1½ horse-power in electricity for each drum, and ½ to ¾ e-power to drive the machine. Mr. C. M. Ball states that Port Henry "Old Bed" ore been converted by means of this machine into a Bessemer ore, carrying iron, 71·10; sphorus, 0.037. This concentration was made from the crude ore, carrying iron, 58·7; sphorus, 2·25; the Bessemer concentrate representing about 65 per cent. of the original s. See Trans. Am. Inst. Mining Engrs., vol. xix. p. 187.

The Wenström Magnetic Separator (Fig. 14) has a stationary field magnet, and an armature rel consisting of a number of soft-iron bars, separated from one another by a non-magnetic material—strips of wood, for instance. The whole is bound together by non-magnetic end rings. The bars are cut away alternately on the inside, to make one bar project only toward the north poles of the magnet, and the next only to the south poles. This gives each succeeding bar opposite magnetism. On each of the four sections of the magnet are wound 15 lbs. of copper wire. An Edison dynamo furnishes a current of 10 amperes and 33 volts. The ore is fed to the barrel by means of a hopper, as shown in outline, Fig. 14, the cylinder turning in the direction of the arrow. The magnetite adheres to the bars of the barrel and is carried downward past the first delivery chute. Below the machine, the bars, departing om the influence of the electro-magnet, which is placed centrically, lose their power to hold the particles of mag- etic iron ore, and they drop off. The particles of rock in the re, being non-magnetic, drop from the barrel almost imme- iately and fall on the first chute shown in the engraving.



IG. 14.—Wenström magnetic separator.

The Edison Unipolar Non-contact Electric Separator Fig. 15) differs from other magnetic separators in that it as no moving parts, except such as are essential for adjust- ent of the apparatus in treating different ores. The parator consists simply of a hopper, a magnet, and a par- tion to separate the concentrates and tailings into different ceptacles. The illustration shows but one hopper, but in ractice the ore can pass on each side of the magnet, thus oubling the capacity. The ore, after being properly crushed nd sized, is placed in hoppers, from which its discharge is ontrolled by bars closing slots which extend the length of ne hopper. These slots are made adjustable, so as to suit ne size to which the ore has been reduced. The hoppers e adjusted to appropriate heights above the magnet. The magnet is a mass of soft iron, ft. long by 30 in. wide and 10 in. thick, weighing 3,400 lbs., and wound with 450 lbs. of opper wire, the coil being connected with a dynamo consuming 2½ horse-power, and requir-

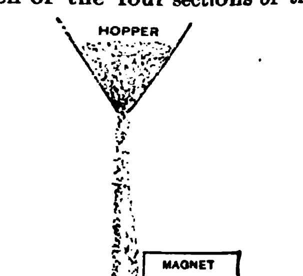
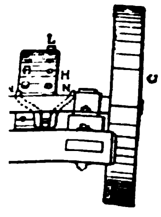


FIG. 15.—Unipolar electric separator.

Joseph Lead Co.," by H. S. Munroe, *ibid.*, xvii. 659; "Velocity of Bodies fic Gravity falling in Water," by R. H. Richards and A. E. Woodward, *The Metallurgy of Silver*, by Manuel Eissler, 1889.
tails concerning the magnetic concentration of iron ores, see Trans. Am. rs., vols. xviii. and xix., which contain numerous papers upon the subject.
ING. Gold and silver ores are generally bought and sold by sample. In early all the silver lead ores, and much of the gold ore, is sold to public reduction, this custom is followed exclusively, and the methods of ore doubtedly been carried to a higher degree of perfection there than any country. Attached to each smelting works is a sampling mill, in which epared. The usual arrangement of these sampling mills, and the method s follows: The ore, having been unloaded from the wagons or railway e mill, where the lumps are crushed to uniform size, say 1 in., by means Dodge, or some other coarse-crushing machine. The broken ore falls the crusher, whence it is shoveled into barrows and wheeled away to ng-furnace house or blast-furnace house, as the case may be, with the tenth shovelful, say, which is thrown to one side, forming a separate pile ll. With ores of average grade it is customary to throw aside every tenth richer ores, every fifth, or even every third, shovelful is rejected. The g one-third, one-fifth, or one-tenth of the original lot, is then wheeled to which is covered by a smooth iron plate, and quartering is commenced. a paper read by Dr. R. W. Raymond before the American Institute of June, 1891, describes the method of quartering a sample as practiced at g works of the West at the present time:
st shoveled into a ring on the sampling floor, and this ring is then center, each shovelful being carefully delivered upon the summit of the that they shall roll equally in all directions. A conical heap having is pulled down and spread out. The workmen walk round and round h the shovel, as it were, the ore toward them, so that it rolls outward. of the pile is not disturbed, and when this process is finished, the con- a truncated cone of larger base area and 6 in. high. This flat heap pressing a stick or a board held edgewise down into it so as to mark ons. Two opposite quarters are cut out with the shovel and removed. ain mixed, formed into a conical heap, and flattened out as before. This until the quantity has been reduced to one or two wheelbarrow loads. has never been mechanically crushed, it is crushed in the rolls to, say, ize. The quartering is then continued till the sample has been reduced ground, say, to 50-mesh size (after a partial preliminary drying, if nec- grinding in a rotary fine-crusher), and then taken to the assay labora- ighly dried (say, for twenty-four hours at 212° F.), and rubbed fine un- through an 80-mesh sieve. Quartering is then resumed and continued y sufficient to fill three bottles, one of which is for the assay of the omer, and the third for the umpire assay, if such should be required."
orks automatic samplers are used, in which case the original sample nth of a gross lot) is crushed by rolls to a convenient size, say so as to l the crushed ore is raised by a belt elevator to the top of the mill, drum screen, the ore which is rejected being returned to the rolls. crushed to proper size and passes the screen falls through a tube or ded mechanically. The means employed for this all depend upon iple of cutting or diverting the falling stream of ore by means of flanges, fingers, or traveling buckets, in such manner as to obtain any desired proportion of it for a sample. There are numerous automatic samplers in use, but most of them are constructed upon this principle.



ic sampler.

Brunton's Automatic Sampler (Fig. 1), which is one of the best in use, is designed upon a slightly different principle from the others, in that the entire ore-stream is deflected to right or left. This is accomplished by placing a funnel with a large opening at a certain point in the spout. Just below the bottom of the funnel is a diaphragm or switch, the bottom of which is pivoted midway in the spout. The ore falling against this is diverted to one side or the other according as the diaphragm is turned. Outside of the spout the diaphragm is connected with a suitable gear, whereby it can be deflected at any desired interval, say five seconds in twenty-five, or five seconds in fifty, during which time all the ore passing through the sample bin. The first sample is then crushed and elevated. ing through another spout equipped with a sampler of the same are driven at different speeds to prevent any possible error that

will condense 0.897 lb. per ft. per hour. Covered with a good covering like magnesium carbonate, the condensation, according to Mr. Luttgen, will be but 0·084 lb. per ft. per hour, a saving of 0·813 lb. per ft. per hour, or 8·13 lbs. of steam per day of ten hours, for each foot of pipe covered. The covering of 100 ft. of pipe, then, will save in a year of 300 ten-hour days the coal necessary to convert 93.900 lbs. of water into steam. One pound of bituminous coal is capable of making about 8·5 lbs. of steam, so the saving of coal due to the 100 ft. of covering would be 5½ tons per year, which, at $4 per ton, amounts to $22. The real saving will probably amount to more than this estimate in most cases; and it may be said in round terms that the 100 ft. of covering causes each year a saving of its own first cost ($25). Inasmuch as the material pays for itself in a year, and will last indefinitely under ordinary conditions, its advantageousness is beyond question.

An estimate of the waste of fuel in neglecting to cover steam-pipes has been made by M. Le Bour, who, referring to experiments made by M. Walther Meunier, gives the following as the quantities of steam condensed per hour and per year of 300 working days of 10 hours, per square foot of surface for different metals, with steam at about 260° F.

	Lbs. per hour.	Lbs. per year.
Copper	0·576	1,728
Wrought-iron	0·798	2,394
Cast-iron	1·712	2,136

Assuming that it requires an expenditure of fuel of 1 lb. of coal for every 7 lbs. of steam, the annual waste of fuel will be as given below for every square foot of the surface of the steam-pipe, and taking coal at $4 per ton, the loss per square foot of surface will be as in the second column.

	Lbs. coal wasted.	Waste of coal per annum.
Copper	245	$0·49
Wrought-iron	342	0·68
Cast-iron	305	0·61

A few years since, an investigation was made at the instance of the Boston Manufacturers' Mutual Fire Insurance Co., by Prof. John M. Ordway, of the Massachusetts Institute of Technology, upon the non-heat-conducting properties of various materials, some of which may be used for covering steam-pipes and boilers, while others, owing to their liability either to become carbonized or to take fire, cannot be directly applied to such use. The results of this investigation are given as follows in a circular (No. 27, December, 1889), issued by the insurance company to its members:

"In order that the relative merits of the different substances which are offered for preventing the escape of heat from boilers and steam-pipes, or as substitutes for wire lathing and plastering, or for tin plates in the protection of elevator shafts, or of woodwork nailed closely to walls, the following tables are submitted. These tables and extracts are taken from a report made by Professor Ordway. It will be observed that several of the incombustible materials are nearly as efficient as wool, cotton, and feathers, with which they may be compared in the following table. The materials which may be considered wholly free from the danger of being carbonized or ignited by slow contact with pipes or boilers are printed in solid black type. Those which are more or less liable to be carbonized are printed in italics.

Substance 1 in. thick. Heat applied, 310° F.	Pounds of water heated 10° F. per hour, through 1 sq. ft.	Solid matter in 1 sq. ft. 1 in. thick. Parts in 1,000.	Air included. Parts in 1,000.
1. *Loose wool*	*8·1*	*56*	*944*
2. *Live geese feathers*	*9·6*	*50*	*950*
3. *Carded cotton wool*	*10·4*	*20*	*980*
4. *Hair felt*	*10·3*	*185*	*815*
5. *Loose lamp-black*	*9·8*	*56*	*944*
6. *Compressed lamp-black*	*10·6*	*244*	*756*
Cork charcoal	*11·9*	*53*	*947*
White pine charcoal	*13·9*	*119*	*881*
Anthracite coal powder	*35·7*	*506*	*494*
Loose calcined magnesia	**12·4**	**23**	**977**
Compressed calcined magnesia	**42·6**	**285**	**715**
Light carbonate of magnesia	**13·7**	**60**	**940**
Compressed carbonate of magnesia	**15·4**	**150**	**850**
Loose fossil meal	**14·5**	**60**	**940**
Crowded fossil meal	**15·7**	**112**	**888**
Ground chalk (Paris white)	**20·6**	**253**	**747**
Dry plaster of Paris	**30·9**	**368**	**632**
Fine asbestos	**49·0**	**81**	**919**
Air alone	**48·0**	**0**	**1,000**
Sand	**62·1**	**527**	**471**

and the pipe cut either over or under standard size, by making the proper allowance at the graduation. When the dies are set to the proper size, the pipe is inserted through the self-centring vise at the back, with the end to be threaded against the back of the dies, and is clamped and brought central with the dies by turning the hand wheel shown on top of the machine. The crank is then put on to the square end of the pinion, shown in front of the machine, and through it the power is transmitted to the die-carrying gear; as the die is thus revolved a very slight pressure on the lever, shown on top of the machine, causes the gear to recede into the shell and the dies are fed on to the pipe. When the thread is cut to the required length, the machine is run backwards for about one turn, so as to take off any burr that the dies may leave; the dies are then drawn back and the pipe is removed from the machine. The depth of the shell allows a thread to be cut about twice the standard length, and if a still longer thread is desired, it can be cut to any length by loosening the vise and pulling the gear, with the pipe still in the dies, forward, so as to give it a new start as many times as is required. Fig. 3 shows a heavy power pipe-cutting and threading machine on the same principle. The vise for holding the pipe is self-centring, and the dies are opening and adjustable to any variations of the fittings.

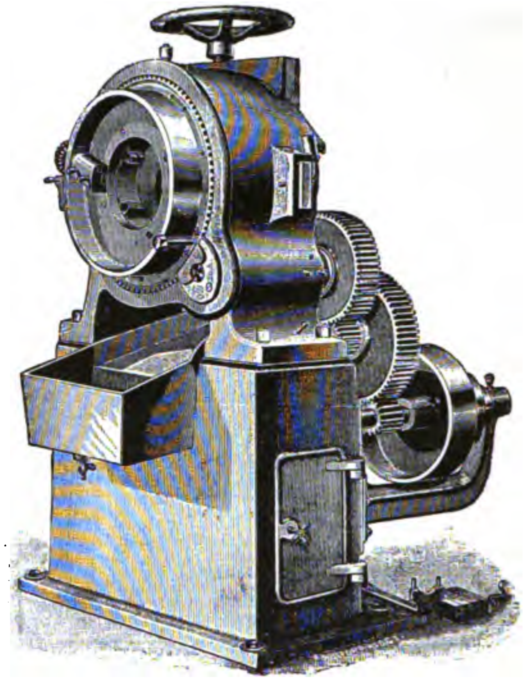


FIG. 3.—Curtis' pipe-threading machine.

Pipe-threading Attachment for Lathes.—Fig. 4 shows an attachment which can be attached to any lathe, within certain limit of size, and with which a lathe can be turned into a power pipe-threading machine in a few minutes, and pipe of any length threaded very rapidly and correctly. This attachment consists of a die-carrying head, attached to the spindle like a chuck; an adjustable, self-centring vise attached to the carriage, and an adjustable pipe rest, attached to the bed of the lathe, to support long lengths of pipe, as shown by the heavy engraving in the accompanying illustration. The pipe is held securely by the vise on he carriage and fed to the revolving dies by moving the carriage. This can be done automatically by setting the lead screws of the lathe to cut the number of threads corresponding to standard of pipe to be cut. When the thread is cut to the length required the dies can be opened by turning the face plate, and the pipe taken out without running back. All the dies are made adjustable to any variation of the fittings, and they adjust from one size of pipe to another, so that each set of dies threads several sizes of pipe without changing.

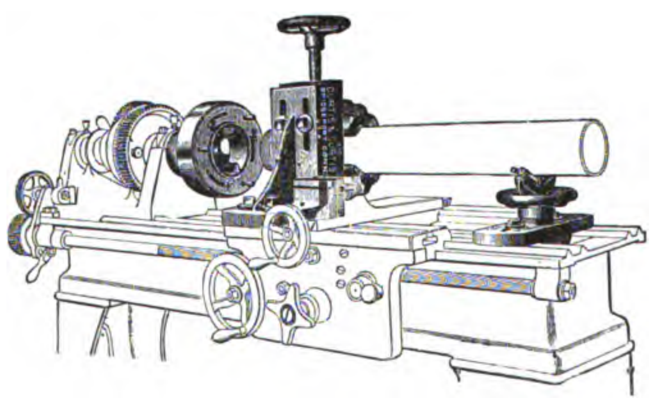


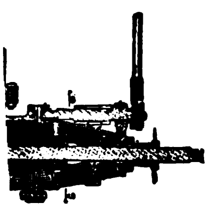
FIG. 4.—Pipe-threading attachment for lathes.

Saunders' Pipe-cutting and Threading Machine.—Fig. 5 shows a pipe-cutting and threading machine made by D. Saunders' Sons, Yonkers, N. Y. It may be run either by hand or by belt. It is arranged so that pipe can be threaded and afterwards cut off, without removing any part of the machine. It is capable of cutting off and threading pipe up to 4 in. diameter, admitting the use of either solid or adjustable expanding dies. The cutting-

›e screwed. In the improved vise, the top half being hinged, pipe sidewise, and saving about half the room that would be required. This side opening is with a further advantage—that ay be used for holding pipes while es, or other fittings are screwed or both ends, or for taking apart ork in which the parts have be- xd together.

Fig. 11.—Tapping machine.

l's Tapping Machine.—A tapping or tapping water, steam, and gas der pressure, shown in Fig. 11, f a case or box adapted to be a main, containing a sliding olding a combined tap and drill, ıd for screwing the corporation the pipe. The carriage is placed :hine so as to have an equal press- and below, and is adapted to ›utside of the case, so as to bring rill or the corporation stud under ›indle, projecting into the case and operated by a handle at the spindle is forced down by the action of a sleeve, outside screw threaded, and passing through a yoke, upon a collar fastened to the said spindle, the yoke being held in position by two studs or posts projecting from the case or body of the machine.



: and tapping apparatus.

Smith's Tapping Apparatus.—Fig. 12 is a sectional view of a machine for tapping water and other pipes under pressure, and connecting branch sleeves, gates, etc. The mandrel or cutter shaft is shown run in and the central drill and tap in position to begin work. After the drill and tap have completed their work of drilling and tapping a small hole in the centre of the piece to be cut out, the hrough the pipe. When this operation is completed, the cut- ;ircular piece cut from the main with it, is run back outside wn or closed. Then the tapping machine is removed, leavy to receive the spigot end of the pipe that is to be carried

eam pipes from non-condensing engines, leading out into the n air, and discharging above a f, are apt to be a nuisance from r discharging with the steam fine ;icles of water and oil. To en- this water and oil, and prevent being discharged on the roof, ıust pipe heads are used, two ıs of which are shown herewith. hat shown in Fig. 1, *A* is the ust pipe; *B B*, branches of the ; *C*, sleeves; *D*, condensing ıber; *F*, deflector; *G*, escape; ›p; *K*, waste or drip.

Fig. 2.—Exhaust pipe head.

the form shown in Fig. 2 the ı is given a whirling motion by l passages, and the centrifugal causes the particles of water and be driven outward against the whence they drain into the drip while the steam is discharged ;h the internal pipe.

arine.

ı, Planing Machine Metals, and Wheel-making Machines.

AL. *The Sellers Spiral-gear Planing Machine.*—At the William Sellers and Co., Incorporated, of Philadelphia, ., which attracted great attention on account of the many

ıd forward motion from an open and cross belt, through a powerful train of cut-gears ıd rack. The proportion of belt speed to speed of table is 44 to 1, and one belt shifts before the other. The feed is obtained by an oscillating disk controlled by stops, and is adjusted by worm and worm-gear. The up-and-down feed can be operated from either end of the cross head.

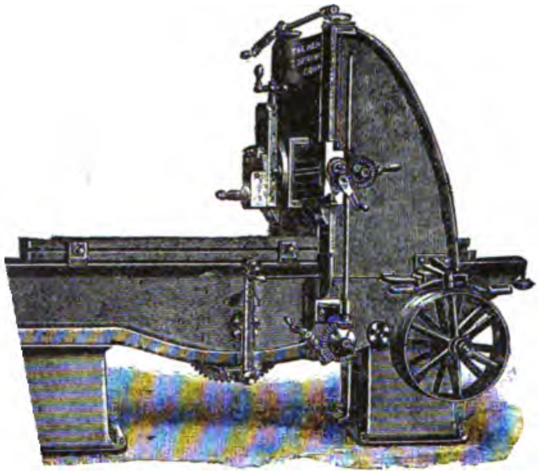
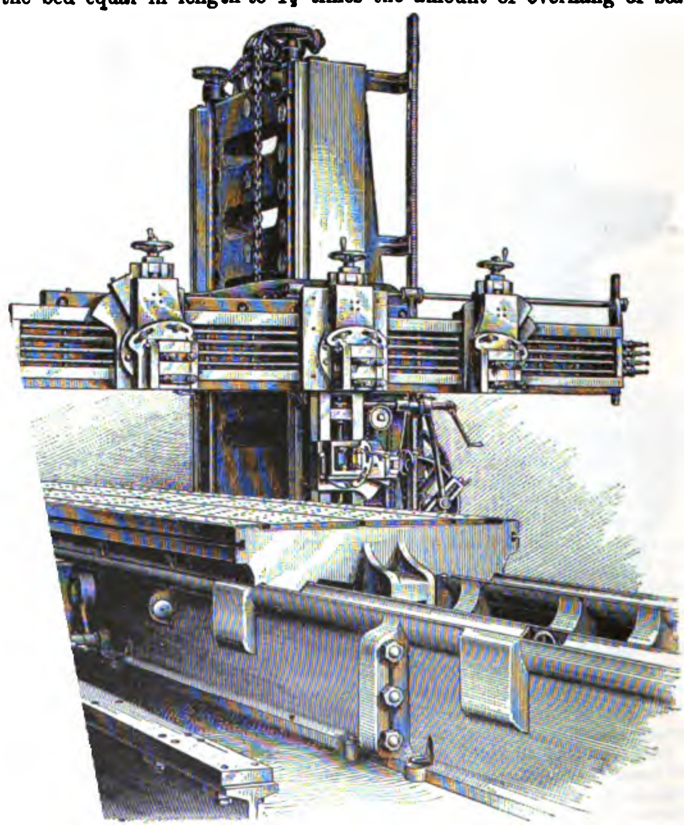


FIG. 2.—The Hendey planer.

OPEN-SIDE IRON PLANERS.—The open-side planer is in no sense a "special" tool, as it does the same work as the ordinary two-post planers of equivalent size. A comparatively small "open-side" tool will, however, plane work which would necessitate a larger planer of the regular style.

To drive these planers, the builders use the Sellers' spiral planer motion. The cross beam is supported by a brace rigidly bolted to back of post. This post eavily proportioned, and is amply strong to overcome any strain. The post g on the bed equal in length to 1½ times the amount of overhang of beam.

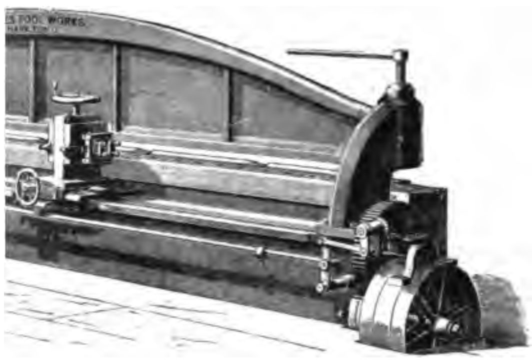


extension planer.—View showing outer post removed.

tomatic feeds in all directions. The beam and cross rail are The builders claim that there is less vibration at end of

'ing gear and pinion have a 7-in. face and 1¾-in. pitch.

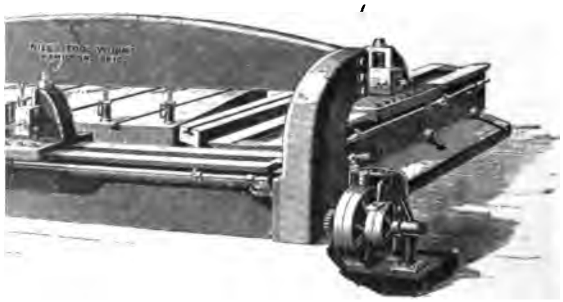
·r and Shaper.—Fig. 4 shows a 36-in. open-side planer
Ayer, of Philadelphia. The construction and general
ne are somewhat different from the usual style of planers
l cutting tool are supported by an overhanging or extended
ed side of bed, and the work to be planed remains station-
: tables as may be required. The open side permits the
s, and as they remain at rest while being planed, they are
would be upon a moving table or platen. The saddle is
illeys, with shifting belts, and has a quick return. For
ide planers have advantages over the ordinary style of



ı.—Boiler-plate planing machine.

lowing: The tools move over the work, which is fixed.
ılaned at the same speed. There are flat surfaces, hori-
ıounting work, so pieces of any shape can be fastened at
ch that the tools stop with the same accuracy as in a
ıe tables, work of any kind can be planed. Pieces of 10
ı 30-in. machine. The heaviest machines can be used for
ιe, without shock or jar.

e Niles Boiler-plate Planing Machine.—Fig. 5 shows a
le by the Niles Tool Works, Hamilton, O. It will bevel
caulking surface, plane plates 14 to 18 ft. long at one set-
r length by resetting the sheet. There are two separate
taken both forward and back. A large steel screw oper-



ı.—Double plate-planing machine.

out from the back of the bed, carrying rollers for sup-
ıg handling. A heavy clamping bar holds the plate
ııised and lowered by screws at each end. No intermediate
ration of setting is quickly accomplished. The driving
ł-in. belt, and strongly geared to the screw. The screw
tch, and is supported in a continuous bearing, preventing
ıtra length and surrounds three-fourths the diameter of

—Fig. 6 shows the Niles double plate-planing machine,
ıdjoining edges of plates at the same time. When plates
l shapes it is of great convenience to be able to do this at
ngle plate planers, when work is to be planed on the end,

ngle, and saves the inconvenience of setting the work at an angle on the shop floor, thus conomizing room.

Newton's Pillow-block Planing Machine is shown in Fig. 9. It is used for planing

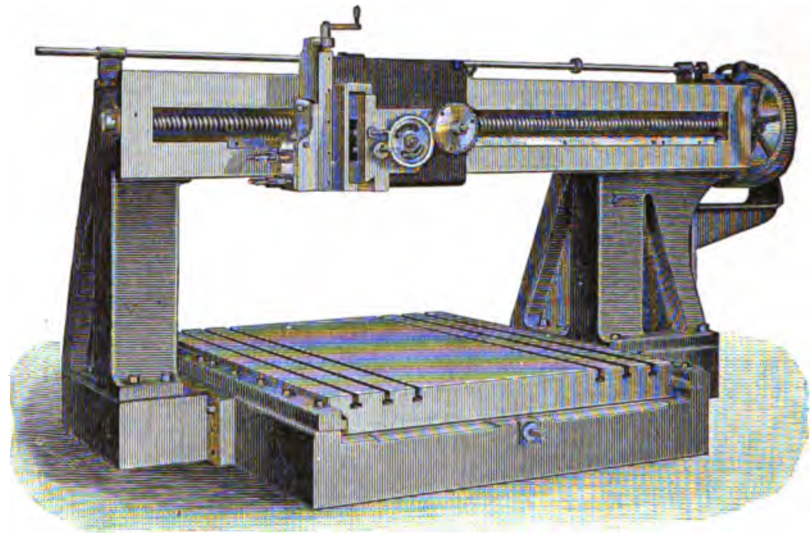


FIG. 9.—Pillow-block planing or shaping machine.

tationary engine beds to admit the brasses, and has an automatic feed both vertical and orizontal, with a range from the finest feed for roughing to a coarse feed for finishing. 'he carriage can be adjusted to set the work. The machine will admit work 30 in. high by ft. wide.

PLANING MACHINES.—WOOD. In considering the subject of planing machinery, re may include therein machines which give to sawed timber proper dimensions, dressing t on all four sides at once, as well as those which merely give it a true surface; and as very nany of those machines which dress it on from two to four surfaces, and give it its finished ridth, make a tongue upon one edge and a groove in the other—matching, as it is called—re must, while studying and describing some types at least of planing machines, study and escribe the matching machine also.

It may be well to call attention to the fact that as regards the tools which work upon the rood, they may be held either in cylinders or in disks; the disks being represented by merely heir radii and the cylinders by mere lengthwise lines upon their periphery, parallel to their xis. Cylinder machines make cuts which are practically straight and at right angles to he length of the stick and to its direction of passage through the machine. The disk or rm machines make cuts which are practically circular arcs bounded by the edges of the tick. In the first class we consider the Woodworth and similar cylinder planers; in the econd, the Daniells. Both of these are illustrated and described in a former volume of his work.

The Modern Daniells planer is built entirely of iron and steel, except the face of the able, which is made of yellow pine. This gives the machine great strength, and especially dapts it to the use of railway, bridge, and car builders, who require to take large lumber or imber cut out of wind or to reduce it to square dimensions. As made by J. A. Fay & Co., he iron frame machine, Fig. 1, has its sides cast in sections, according to the length f machine wanted. The ways on which the table moves are cast with the sides and laned to fit the slides of the table, which are continuous, and form a good bearing at all oints. The table is made to travel in either direction under the cutters by a self-acting notion, and it will plane forwards and backwards. The carriage has a dog or tail-screw let nto the back end of the platen, so as to come below the surface, and is operated by a crank vheel. The main spindle is properly of steel, of large diameter, and running in long bearngs; the arm should be of wrought or malleable iron. The material is held down by dead veights or guide plates. The carriage has side clamps for edging up. The levers for starting, reversing, or stopping the motion of the table, with the hand wheel for raising and lowring the cutters, are all within easy reach of the operator, and the table can be moved by a and wheel when the machine is not in operation. The feed works have three changes of eed, admitting of planing while the table moves in either direction. The rack being eneath the table, with a vertical pinion, there is no danger of lodging of shavings, nor endency to raise the table by the force required to move it. The main driving belt is not a uarter-twist, as in the old makes; the countershaft being attached over the machine to the uilding and parallel to the main shaft, thus giving a straight belt; and the driving belt

ıas a pulley at each end to enable two belts to be used; and
s. The pressure bars on each side of the upper cylinder are
.ng and falling with the feeding-in rollers, and always retain-
ret allowing the roller to yield to any variation in the surface
'olling the pressure after the cut of the upper cylinder being
; the cut of the lower cylinder is adjustable to meet the cut

; machine shown in **Fig. 3**, the cylinders are large and slotted,

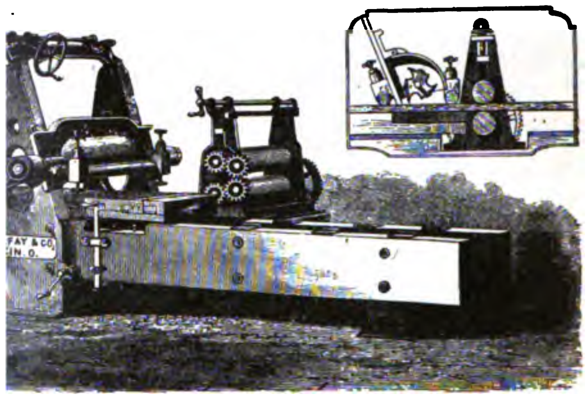


FIG. 2.—Combination planer.

: is a bonnet chip-breaker, and a complete set of pressure bars
ıstment. The lower cylinder may be set for any desired cut,
ring down to admit of easy access to the head for sharpening
l is raised and lowered on four screws by hand or by power;
ljustment of 8 in. is accomplished in one minute. When set
:ylinder, while firmly clamped to the bed, is also clamped to
ars on the feed rollers are of about double the diameter of the
Each pair of feed-roll boxes is connected in a yoke frame to

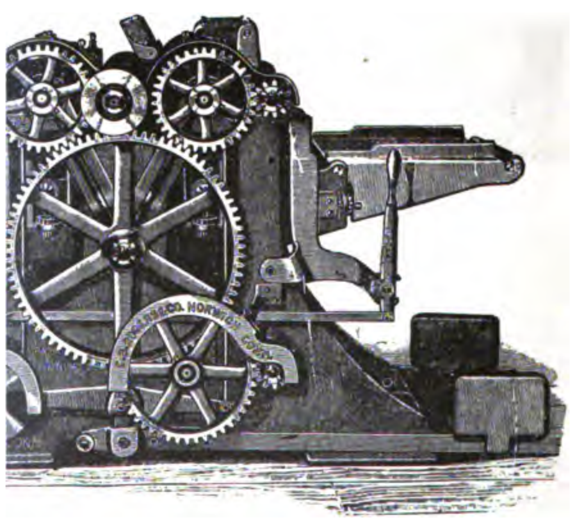


FIG. 3.—The Rogers double surfacer.

ing, and all links are hung on boxes instead of on roll shafts.
:he top cylinder, through two feed shafts provided with cones

r.—In a 26-in. cabinet double-surfacing planer made by the
e are some features which are absent from some others of the
ındersurfacing, the bed is supported on four screws, one under
er, and the curved pressure bar over the underhead is very
ruer work with the undersurfacing head than would be the

nbling while the end of the board is passing from the feeding-in to the feeding-out rolls; the beading head is fitted with saw-teeth knives which remove fuzz from the edge of the d.

The Fay Endless-bed Surface Planer.—A method of feeding the material in wood planers, ering from the hand, carriage or platen, and pressure-roll methods, is by an endless bed, hown in Fig. 4. It is especially desirable for green, wet, or icy lumber; and the demand this type is constantly increasing in this country. There is an endless apron or bed of s driven by heavy gearing, and remaining in a fixed position at all times. The lags or ps composing it are of cast-iron, but the bearings on the ways are plated with steel. The nder is of large diameter, lipped with steel, and carries three knives, and pulleys for two s. It runs in self-oiling bearings in a cylinder frame which is raised and lowered by a d wheel. A weighted pressure bar is placed before the cut, as is also a pressure roller plied with springs which give an elastic tension, that is controlled by a screw and hand :el, so as to give any desired pressure. The cylinder frame carrying the cutters is gibbed he sides. The cylinder and pressure bar adjust simultaneously to the thickness of cut, by ngle movement of the hand wheel. The feed is started and stopped by a binding lever. evelopment of this machine, of much heavier build, for planing-mills, bridge work, etc., a stationary cylinder so that the countershaft may be either on the floor or overhead, as ired. There is a chip-breaker for holding the fibre of the wood during the process of cut-;, and a pressure roller in front weighted with folding levers so arranged that either end work independently of the other, which is desirable on unevenly sawed lumber. This

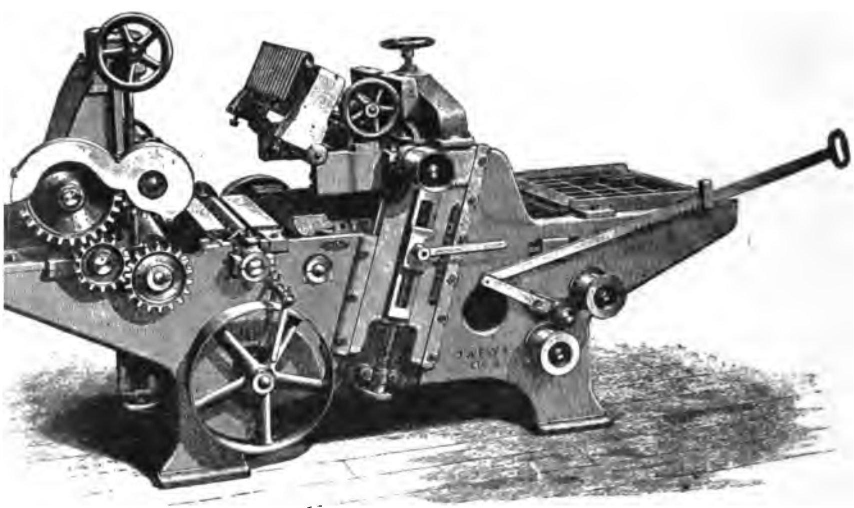


FIG. 5.—Endless-bed surface planer.

ws the rollers to adjust to the different thicknesses of the lumber without unduly strain- any of the parts of the machine.

Ƭhe machine shown in Fig. 5 has the line of the bed in a fixed position, the upper and lower cylinders, and the pressure bar over the latter, adjusting simultaneously to suit the kness of the timber. The upper cylinder carries four and the lower one three knives, either can be raised or lowered when running. The pressure bar over the lower cylinder inged, and can be swung back out of the way to give free access to the cutters. There is :t of heavy delivery rollers after the lower cylinder, driven by expansion gearing, and :ing the lumber away from the machine, thus relieving the strain on the travelling bed ecding heavy lumber. There are two speeds of feed, 40 and 60 ft. per minute. The feed :rs are broken in their length, so that either one wide board or two narrow ones of qual thickness may be planed at once. The cylinders have chip-breakers. A uniform tic pressure may be maintained by pressure springs. The pressure bars before the cut are ional, one for each divided roller, and are raised simultaneously with the upper cylinder.

Ɔther Endless-bed Surfacers.—In a machine made by the Egan Co. the heads instead he bed raise and lower; the upper head being belted from each end and raising and :ring from the working end of the machine. Each slat of the bed or travelling apron on the under side a circular wedge, extending between the two bearings to give stiffness; as each end of each slat passes under a rib of the full length of the bed, it is impossible it to lift it into the cutter head even when planing the thinnest stock. The pressure istment, including the two pressure rollers, is raised and lowered with the cylinder to the thickness of the material being planed. The lower cylinder has a pair of feeding-rolls.

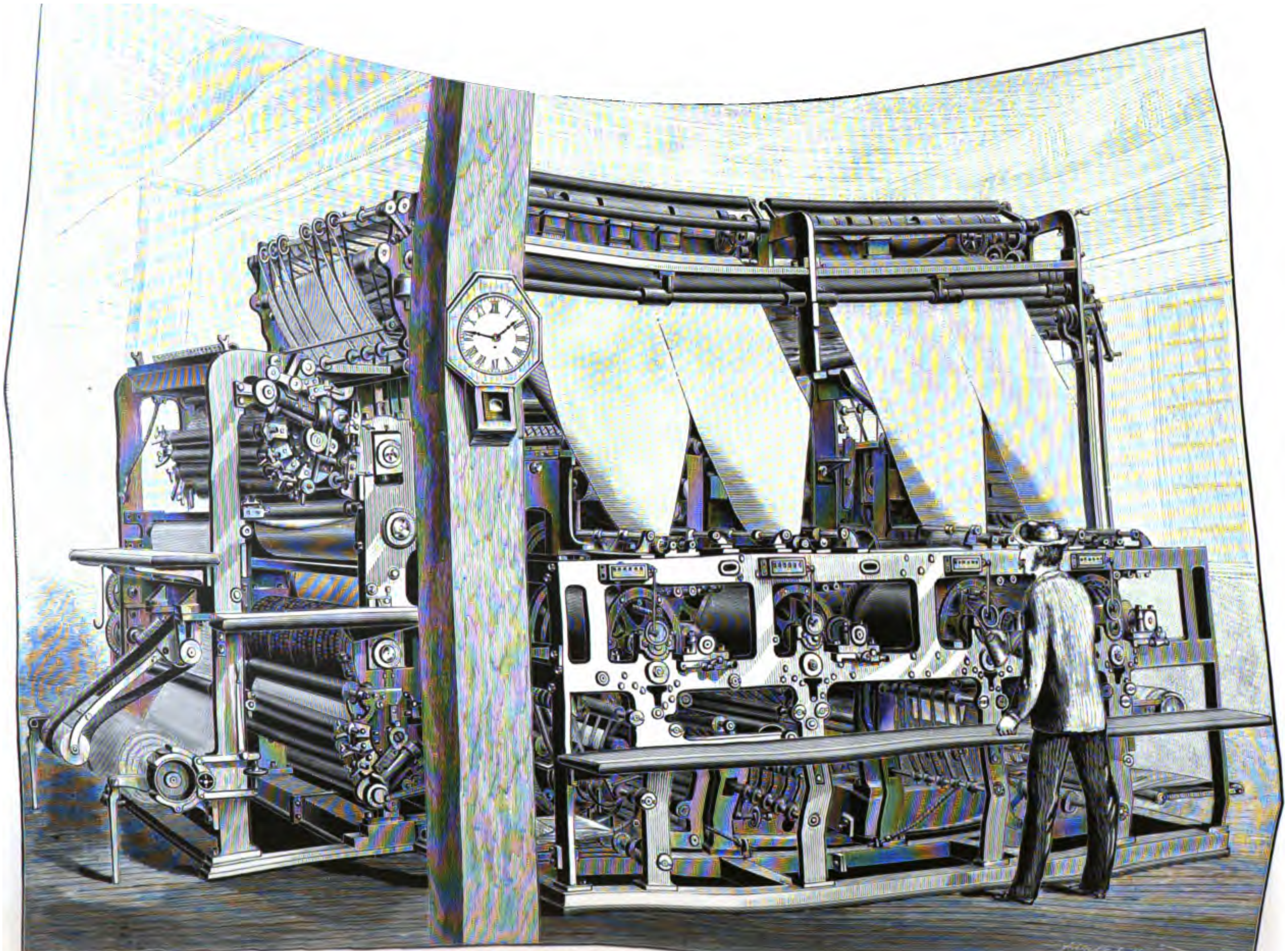
ı one type of the double-cylinder, endless-bed surfacer, the endless bed itself extends

t stationary bed just under the cutter head; then beyond
ıother travelling bed for feeding out the material. Where
y one set of rolls for feeding-in and another set for feeding-

ng machines and similar tools having heavy carriages carry-
ally considered safe to control the carriage movement by
ting belts, or a friction feed, are employed.
ning Machines.—In the construction of the planing machine
m to have arisen to the fact that such machinery should be
are giving them heavy plate sides with internal ribs; they
holes, turn the bolts, and in every other possible way design
lo accurate work at high speed with heavy cut, without danger
o lose accuracy of work. It is best that the cylinders of planers
made of steel, with the spindles drawn out from the body of
ders and the spindles in one solid piece.
the lower feed rolls are double the diameter of the upper, their
g the same. It is claimed for this arrangement that it gives the
uses it to enter and leave each pair of rolls with greater smooth-
e gears are always placed on the "gauge" side of the machine,
e front side of the roll, so that the driving pressure will be down-
pressure on the gauge side, which is by some thought desirable.
aning and matching, the matcher frames and spindles are dropped
rom working flooring to surfacing; in others the change is made
heads from their spindles, thus leaving the matcher frames and
orking position. In operating planing and matching machines,
nning the side or matcher heads against the feed, as it takes less
ay, and the cutters are kept in order longer, not coming in contact
y be on the edges of the lumber. In some machines the back part
and supports the cutting edge, is of circular form, to conform to the
ich carries them.
nt in the way of safety of high-speed planing machinery consists
which drive the feed rolls by a casting conforming to their outline.
likely to damage than the sheet-iron or tin casing that is some-
not found often enough on machines of this class.
rs and Drills.
year 1880 the improvements made in the plow of the ordinary type
the materials and manufacturing methods. Modifications of form
nor details, important as increasing efficiency and durability, without
form. Cast-steel and chilled iron have been liberally adopted for the wearing parts of plow bottoms, and the advantageous skilful manipulation of these materials is naturally confined to large and costly establishments, in which alone can the forming and polishing of the mould-board be done with due preservation of the evenness of the temper and conservation of the greatest percentage of good wearing surface. The hydraulic process of "chilling" is the most pronounced improvement in the manufacture of plowshares during the last decade. It cheaply secures uniformity and exactness of contour and extreme hardness of surface. Fig. 1 shows a result of one of the applications of the process. In this instance the under skin of the metal, shown white, is chilled to extreme hardness, and the upper portion of the material left comparatively soft; so that, in plowing, the upper face of the share wears away next the edge enough faster than the under face to yield a continuously sharpened edge of the

illed plowshare.

avoiding the heavy draft of a dull share without the need of the usual
the smith to have it sharpened. Mr. James Oliver, who has been prominent in
and manufacture of chilled-iron plow bottoms, states that his first success
water in the chills, drying the moisture in the foundry flasks and preventing
next success was in ventilating the chills by introducing grooves along the
d, which allowed the escape of the gases which form within the flask when
oured in, letting the liquid metal come in direct contact with the face of the
surface, thus removing all the soft spots in the mould-boards, and leaving
oth and perfect; but that his crowning success was in the use of the anneal-
ich deprived the metal of its brittleness. Malleable iron is now used for the
w. It unites the advantages of economical manufacture and "interchange-
to the uniformity easily attained in malleable iron pieces, every frog fitting
same pattern in case of necessary repairs. Welded frogs or those forged
ron are liable to spring in manufacture or in use; and if it becomes necessary
with a new land-side or mould-board an expert smith is required to fit the



THE HOE SEXTUPLE STEREOTYPE PERFECTING PRESS, WITH FOLDERS.

f the bed as it passes the center, but with the assistance of the governor and relieves the gearing of es aids in starting the bed on its return movement, and with both of the hol- ain. By the governor valve, in the air-pipe connected low piston rods, the amount of spring pressure is controlled, the gate being kept either wholly or partially open or closed, according to the position of the governor balls as affected by the speed of the press.

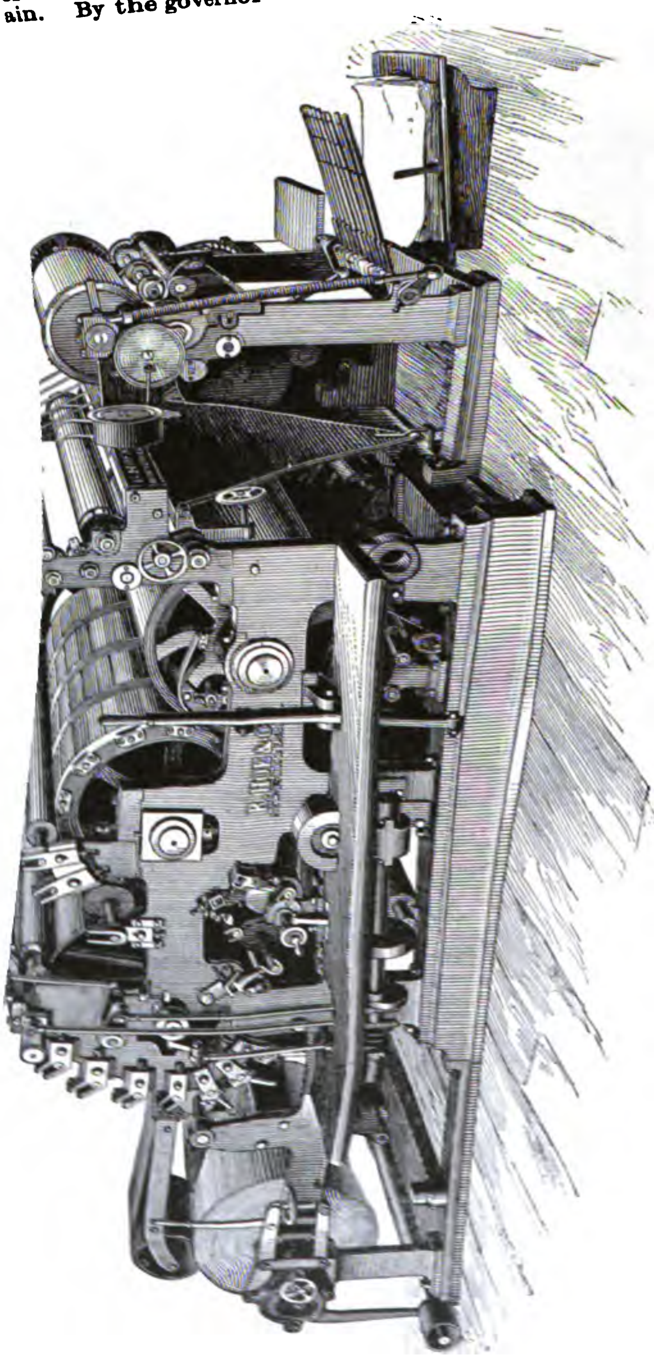


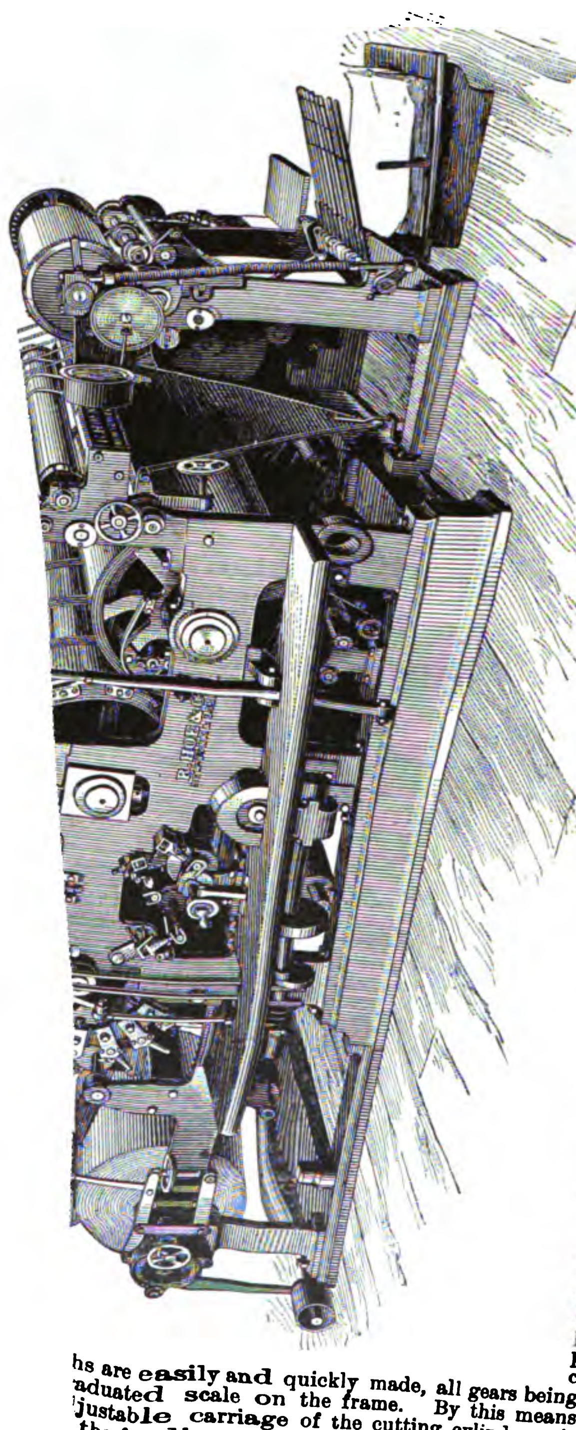
Fig. 4.—Prudential press.

The Potter Flat-bed Perfecting Press (Fig. 5).—This improved press combines the well-known advantages of the Potter two-revolution press and the perfecting press, which print from flat forms, either type or plates, a high-grade work, economically and profitably.

The general mechanical movements of this press are the same as those of the Potter two-revolution press. The driving mechanism and the patented method for controlling the raising and lowering of the cylinders and regulating the impression, are identical with the two-revolution presses. Some of the distinguishing points of this press are:

The feeding and cutting device for roll feed: as will be seen in the engraving, the paper is taken from a roll at the end of the press and led into forwarding rollers, which in turn carry it between the cutting cylinders, thence on through another pair of rollers, which have the web under full control until the sheet is cut and seized by the grippers of the feeding cylinder. The cutting and feeding mechanism, claimed to be the only one by which sheets of various sizes can be cut and carried positively to the grippers: the changes necessary for cutting ts of different lengths are easily and quickly made, all gears being plainly marked so as orrespond with a graduated scale on the frame. By this means, in connection with ndex finger on the adjustable carriage of the cutting cylinders, the relative position of cutting cylinders to the feeding cylinder, as the size of sheet is varied, is easily deter-

entum of the bed as it passes the center, but with the assistance of the governor and ım valves aids in starting the bed on its return movement, and relieves the gearing of ıdue strain. By the governor valve, in the air-pipe connected with both of the hollow piston rods, the amount of spring pressure is controlled, the gate being kept either wholly or partially open or closed, according to the position of the governor balls as affected by the speed of the press.



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der when stopping and starting. This change admits of the press being
gher rate of speed. The feed guides have been removed from the feed
iany disturbances are liable to affect the register, and have been placed
elf and revolve with it. The angle of the feed board has been so changed

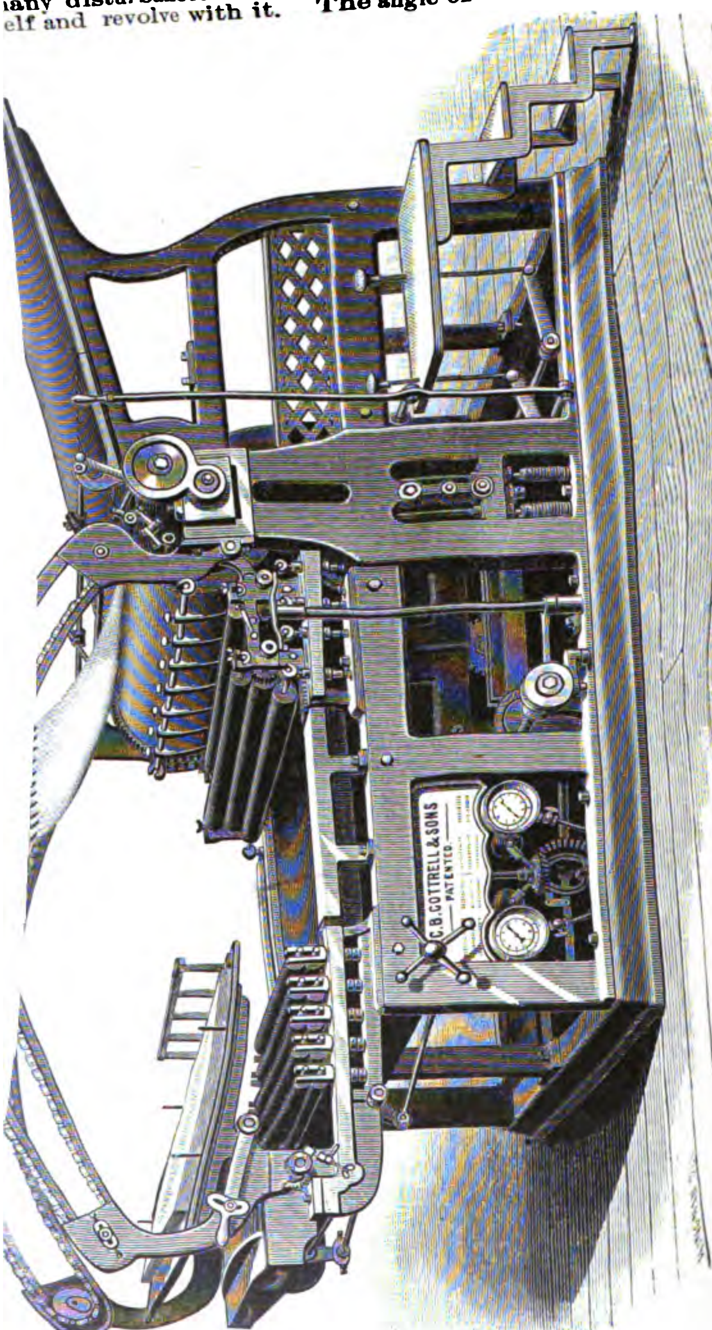


FIG. 6.—Cottrell two-revolution press.

n nearly a horizontal position when fed to the guides, thus preventing any
sheet when the grippers close on it. This press is also arranged with the
ature, enabling the feeder to throw off the impression if a sheet is not fed
uides, also enabling him to roll the form any number of times to each
neans of a reverse motion, the feeder is able to "back up" the press with-

ı turn leads the web between a pair of cutting cylinders to sever it into sheets, and pers of the band take the sheet from the cutting cylinders and at the proper time ; so that it may be deposited with the pile on the piling table.

Hoe *Single Web Perfecting Press* has two form cylinders, each carrying four pages of a newspaper, printing two complete copies of a four-page paper at each revolution—speed, 24,000 per hour—or the eight plates many be so arranged on the two cylinders as to print one eight-page paper at each revolution—speed, 12,000. Papers are delivered, folded, and counted automatically.

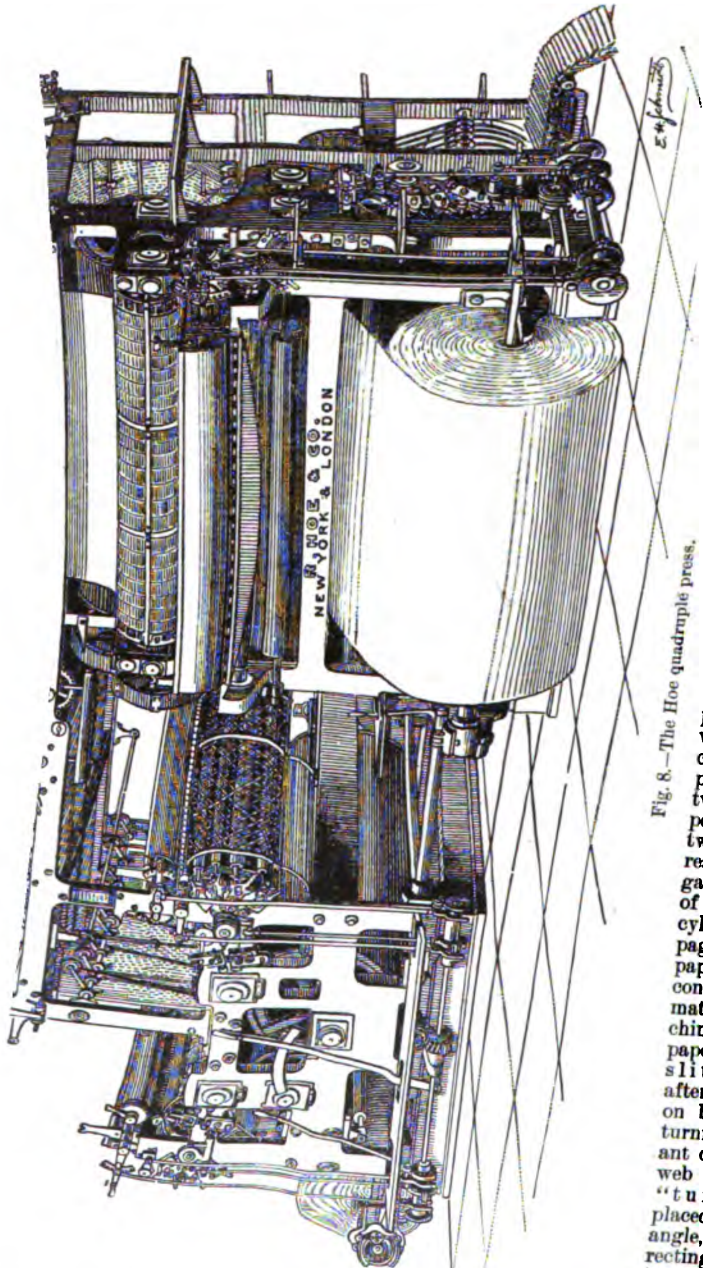


Fig. 8.—The Hoe quadruple press.

The Hoe Three-page-wide Press has two form cylinders, each carrying three plates lengthwise of each cylinder and two around it. The following productions result: From a two-page-wide web, printing from only four plates on each cylinder, 24,000 four-page or 12,000 eight-page papers per hour. From a three-page-wide web, printing the whole width of the machine, 24,000 six-page or 12,000 twelve-page papers per hour; eight and twelve-page papers resulting from the gathering, by means of the Hoe collecting cylinder, of 2 four-page and 2 six-page papers respectively, containing different matter. On this machine the six-page papers are made by slitting the web, after being printed on both sides, and turning the resultant one-page-wide web by means of "turning bars" placed at the proper angle, and so directing it under the two-page wide web, just before it enters the folder, that the single sheet is folded vo-page-wide one and secu ɔd down the center margin of the latter by a line three-ply web is cut transversely, folded, and delivered exactly as a four-page

uble Stereotype Perfecting Press has eight stereotype plates on each of the ers ; four plates, lengthwise each cylinder, and two round the circumference

other roll; the rolls being intermittently moved, one to unroll a small portion of the cloth, d the other to roll up a like portion, thereby presenting a fresh wiping surface below the d. There are a number of these pads extending transversely across the machine so as to ar the cloths upon the plate as the latter travels beneath them. These pads were given a nstant transverse reciprocating motion, so that the cloths were rubbed over the surface of inked plate as the bed moves forward into the plane of impression with the cylinder. The te is kept constantly heated by gas jets burning below the bed; and in some cases one or re of the wiping cloths is dampened by passing the cloth through a water trough, the

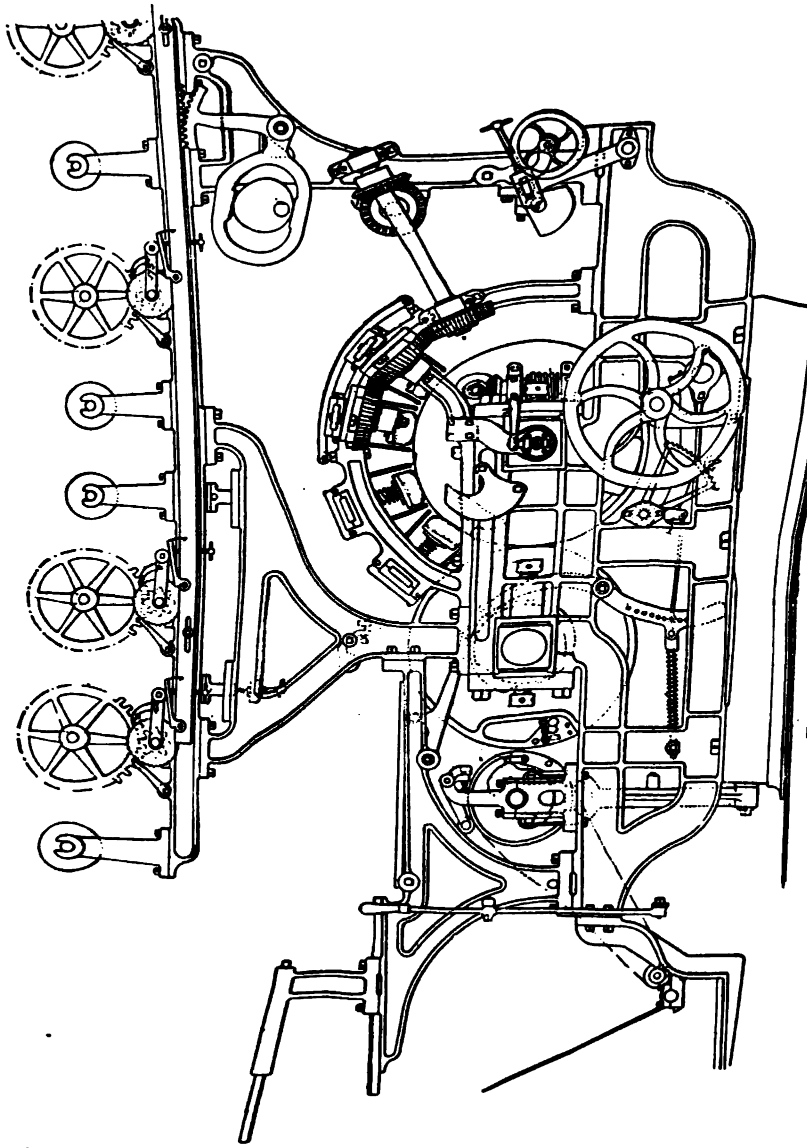


Fig. 9.—Rotary plate-printing machine.

water absorbed thereby being regulated by a squeezing roll; and finally the last e one nearest the impression cylinder, has or may have its cloth omitted and the chalk its under surface so as to give the final polish to the plate just before printing; lso in some cases is employed with this pad, and in this case the cloth has chalk lly applied to it instead of to the pad. The sheets to be printed are fed by a girl sual feed-board to the grippers of the impression cylinder, and after being printed elivered in the usual manner.
t-bed plate-printing machine has met with great success in printing many difficult

s for quickly adjusting same. The adjustment of the blank-holder ir steel screws. In the larger sizes, power is communicated to the back shaft through a powerful friction clutch, which, in connection with the automatic brake, places the movements of the press entirely under the control of the operator, so that the press can be stopped and started instantly at any point of the stroke.

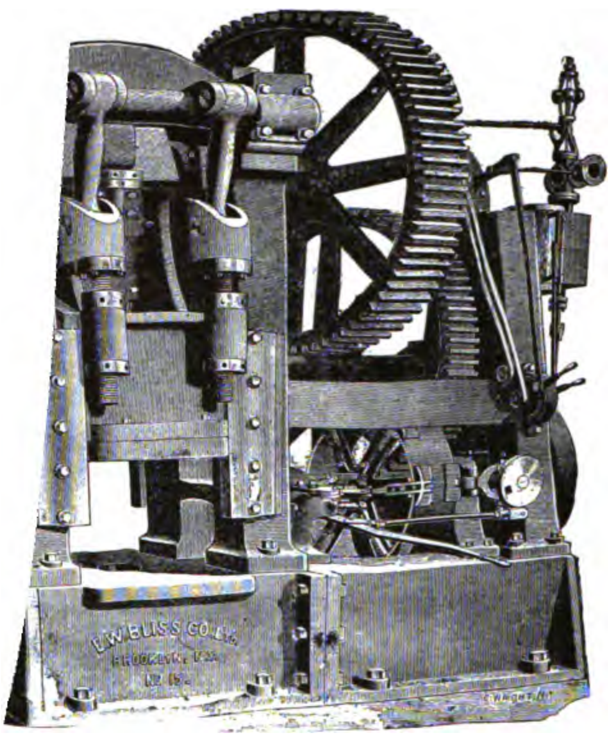
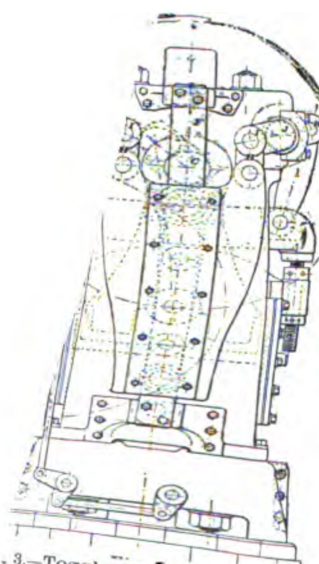


Fig. 2.—Toggle drawing press.

Fig. 1 shows one of the smaller sizes of press made by the E. W. Bliss Co. This press is adapted for operating double-action dies in the manufacture of brass, tin, and other sheet-metal shells not exceeding 8¼ in. in diameter or 1¼ in. in depth. This includes a large variety of lamp and burner work, tin boxes and covers.

Manufacturers of metal goods of various kinds have discovered that many articles which have heretofore been produced by casting them, or by expensive processes of forging, can be made s of cold drawing, provided the proper machine is constructed, and the tools



. 3.—Toggle press. Elevation.

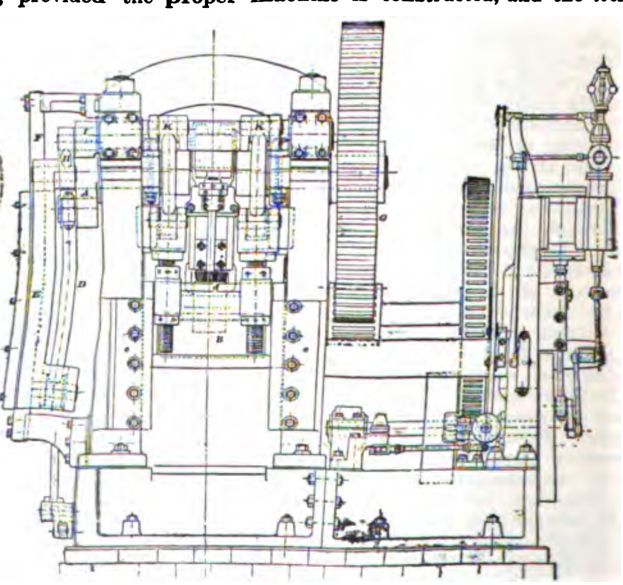


Fig. 4.—Front elevation.

with it are made with due regard to the behavior of the metal worked in the drawing s. Many comparatively thin and light articles, which have heretofore been cast, are

shown in the diagram, the plain body of the central portion of the valve, with a cup leather on each side, being all that is exposed to the great pressure.

The press ram makes a stroke of 2¼ in., and its diameter is 30 in., so that at a pressure of 3 tons per sq. in. (deducting the area of the shank) we have a power of 1,700 tons.

A Forging and Bending Machine, of novel form, made by Williams, White & Co., of Moline, Ill., is shown in Fig. 3. The cut shows it as arranged with dies for bending arch bars for freight cars. The machine is a horizontal press, of massive proportions, adapted to be used with a great variety of forms and dies which can be changed at pleasure. The cross-head moves back and forth on the bed. The pitmans are driven by wrist-pins attached to the main gears, of which there are two—one on each side of the bed. By this method both ends of the cross-head move the same distance in the same time.

Forging Compressed Steel for Guns, Shafts, etc.—In order to overcome the want of soundness in steel when cast and forged in large masses, Sir Joseph Whitworth, at his works near Manchester, Eng., introduced the system of consolidating the steel ingots while fluid under hydraulic pressure, and then forging them on a mandrel by a hydraulic press.

A gradually increasing pressure up to 6 or 8 tons per sq. in. is applied, and within half an hour or less after the application of the pressure the column of fluid steel is shortened 1½ in. per foot, or one-eighth of its length; the pressure is then kept on for several hours, the result being that the metal is compressed into a perfectly solid and homogeneous material.

The same system has been recently adopted by the Bethlehem Iron and Steel Works, U. S. A., and by a number of works in England. Open-hearth steel is generally used. The mode of working is thus described by E. H. Carbutt, in his presidential address before the Institution of Mechanical Engineers in May, 1887:

An ingot of the requisite size up to 65 tons is cast either round, or square, or hexagonal, according to the views and experience of each steel maker. The hexagonal form, with sides slightly curved concave, is preferable, because the sides can then follow the shrinkage of the material in cooling, and thus prevent internal rupture of the metal. The ingot, being upright during casting, is cast longer than necessary, so as to get the effect of a head to allow for the steel shrinking as it cools; the head is afterwards cut off in a lathe. The ingot in cooling drives the carbon to the center, so that when cold it is found that although the steel on the outside is mild enough for a gun forging, the center is hard enough for tool steel, containing 0·8 per cent. of carbon. This hard center is then bored out of the ingot, until the test shows that the inside of the annular ring contains the same percentage of carbon as the outside. The center being bored out allows an internal, as well as an external, examination of the ingot. The hydraulic press is then brought into play on the annular ring, with the full advantage of being able to forge on a mandrel. The amount of material which is cut off and bored out of the ingot is so large that it leaves the forging only one-half to two-thirds the weight of the ingot. This loss of material accordingly adds to the cost of the forging.

The hydraulic forging presses vary in power, working at 2½ to 3 tons pressure per sq. in., and having steel cylinders from 35 to 40 in. diameter, with 4½ to 7½ ft. stroke. In several of them the head which contains the cylinder is movable, so that in forging a large mass the cylinder is lifted up and only a short stroke is necessary. The presses are worked direct by large pumping engines, without the intervention of an accumulator, the engines running only while the press is at work. The cranes all have an arrangement for turning the porter-bar, so that the forging is rotated between the blows of the press. There can be no question that the introduction of the hydraulic forging press has been a great means of overcoming the difficulty of making large steel forgings. The pressure is so great and so equal throughout that the steel in the center of the ingot is worked at the same rate as the outside; that is, while an ordinary steam hammer would draw the outside only and leave the centre unworked, thus bringing about internal strains in the steel, the press acts on the whole mass equally throughout.

PRESSES, HAY AND COTTON. *Hay-baling presses* are operated by steam-power or by

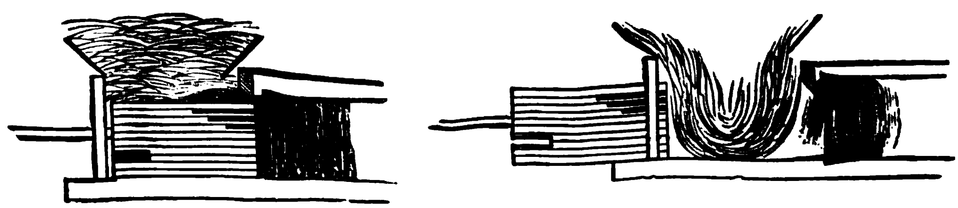


FIG. 1. The Dederick press. FIG. 2.

horses, and are made in some variety, but all on the plan of compressing small charges in detail consecutively into a long, horizontal, square-cornered box by strokes of a reciprocating

where from 1 ft. to 5 ft. long. With one horse 6 tons, or with two horses 8 tons, may be baled in a day. The bales made by these presses load and stow with economy of labor and space, and in use the layers of hay are neatly separable. Recent rapid adoption of high-speed, reliable hay-baling presses has caused a decided change in methods of handling the great hay crop of the country, by making it an extremely available shipping commodity, extending areas of consumption, and steadily shifting areas of production westward in the United States, to the prolific, grass-growing prairie regions where the broad, level stretches of land are peculiarly suited to the use of machinery.

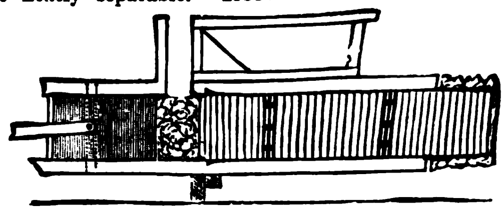


FIG. 9.—Cotton-baling press.

Cotton Press.—Dederick makes a press on the same detail ramming plan, for baling cotton on the home plantation or elsewhere. Its operation is exhibited in Figs. 7, 8, and 9. It does away with the usual necessity of re-pressing for ocean shipment, as it produces extraordinarily condensed bales, straight-edged and flat-sided, without bilge or any expansion when released. As compared with cotton treated by the customary pressing and repressing, claims are made that the fiber of the cotton pressed in the Dederick press is less crushed, as the detail compression admits of a lower maximum of pressure, and that the work is more rapidly done and is less expensive. The capacity of a press is 400 or more of "quarter" bales daily. The average weight of a bale is 125 lbs., and measurement $12 \times 15 \times 30$ in. $= 5,400$ cub. in. The ordinary 500-lb. bales, to be equally condensed, would measure but 21,600 cub. in., whereas they are stated as a matter of fact to exceed 33,000 cub. in., average, even after re-pressing. It should be added that the new quarter bales come apart, when opened at the mill, in sections suitable for the picker. They may, if desired, be ejected by the press directly into sacks or covers. Fig. 10 illustrates size and shape of a "quarter" bale in comparison with a man.

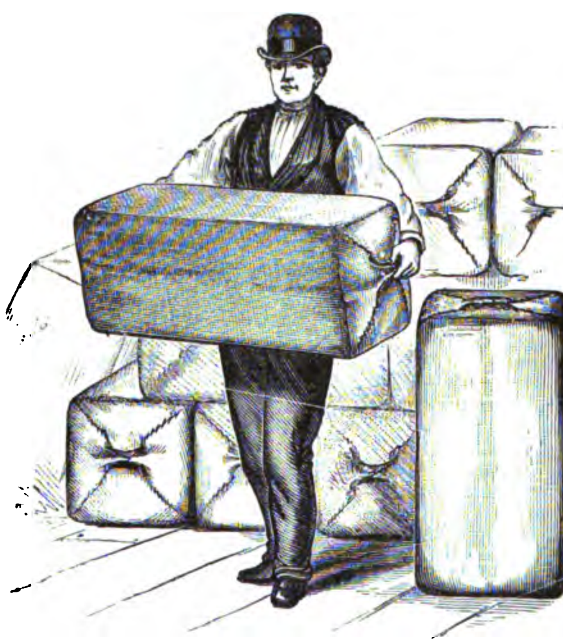


FIG. 10.—The "quarter" bale.

PROJECTILES. (See also, ARMOR; ORDNANCE; GUN, PNEUMATIC.) *Material.*—A little more than twelve years ago chilled cast-iron projectiles were considered all that could be desired for work upon the wrought-iron armor of that period, and, in fact, an extensive series of experiments made in England tended to prove that against this type of armor the chilled iron was fully equal to the steel shell in normal, while it was slightly superior in oblique fire. These experiments also included tests of chilled-iron projectiles against steel plates, with the result of a decision being reached that "steel shell are absolutely necessary for the attack of steel-faced armor." France and Germany were the earliest in the field with steel armor-piercing projectiles.

In the first-named country several concerns are engaged in shell making, each practicing some special mode of treatment, or using some particular chemical combination. At Terre Noire, for example, the steel is oil hardened, but not forged, and the quality varies in different projectiles, being softest in the largest calibers; but the degree of hardening varies also, so that the final product possesses nearly the same degree of hardness in all cases. St. Chamond projectiles are generally made of crucible steel, forged, and oil hardened; but here the quality of the steel is the same for all calibers, and the hardening process differs. That for the 34-cmt. shell is described as follows: The projectile is brought to a cherry-red heat throughout, plunged in oil, and kept immersed until cold; it is then brought again to a cherry-red and dipped in cold water as far as the front band, where it is kept eight or ten minutes; finally it is wholly immersed in oil until cold.

Krupp projectiles are of crucible steel, and the final process is oil hardening; it is said that a file will not bite anywhere on the surface. The use of steel has lately been

an inch; the third did the same, and was shortened .14 of an inch; the fourth acted in the same manner, but was broken up. The compound plate let the first three through without injury to the projectiles, but the fourth broke after perforation. The body of the first shell fired at the nickel-steel remained in, but the rear end rebounded; the second remained intact in the plate; the third the same, excepting that the base projected 4·5 in.; while the fourth broke, leaving its head in the plate, the rear portion rebounded. A fifth shot was fired at each plate, the projectile being an 8-in. Firth-Firminy. The one fired at the steel plate penetrated, rebounded, and broke in three pieces. The nickel-steel let the projectile enter, but broke it 5·25 in. from the face of the plate, part of the head remaining in the hole. The shell fired at the compound plate was recovered entire, but was shortened 0·24 in.; much of the plate was damaged, the hardened front portion was scaled off in a number of large and small pieces.

In the Ochta trials the first two projectiles used were of poor quality, but the last three were excellent, and a comparison with their performance against a Vicker's plate and the Schneider steel plate at Annapolis shows that in the former the points of the three projectiles penetrated 7,11, and 4 in. beyond the back of the plate, while in the latter the penetrations of the four 6-in. projectiles beyond the back of the plate were respectively 2·75, 2·4, 2·0, and 2·4 in. Against the nickel-steel 10-in. plate the Holtzer 6-in. shot first fired penetrated 9 in., and rebounded, broken in two; the second penetrated 8¾ in., and rebounded, broken in three pieces; the third went in 11¼ in., and rebounded unbroken; while the fourth entered 9¾ in. and broke in two. The first at the compound plate entered 18·2 in. and remained entire in the hole; the second did likewise; the third perforated plate and backing, and was found unbroken 817 yards to the rear; and the fourth was intact 983 yards to the rear. The two nickel-steel plates differed somewhat in constitution, containing unequal proportions of nickel, which will account for the different effect upon the projectiles.

The most important struggle between armor and projectiles in this country took place in 1891 at the new naval proving grounds at Indian Head, on the Potomac River. In this the plates were of domestic manufacture, and a portion of the projectiles used were also made in this country. Six plates were used, four 6-in. and one 8-in. projectile being fired at each plate under circumstances similar to the trials already referred to. The general result to the projectiles was in the main like that of the trials at Annapolis, and a positive proof was given of our ability to improve on original designs and to obtain in this country all the armor-piercing shell that we need.

The Carpenter projectiles are made of chrome-steel, after the Firminy process; that is, all of the patents covering that process were purchased for use in this country; but something better was expected, as the conditions of the armor were changed first from steel to nickel-steel, and then from the ordinary methods of hardening to the adoption of the Harvey system. Consequently experiments were started in hardening the head of armor-piercing shell, and departures were as a natural sequence found necessary. The tempering does not run to the same extreme throughout the shell, as the thinner walls about the powder chamber would not stand the treatment and maintain the desired degree of efficiency; the head, and as far down as the chamber will admit, are treated, and the projectiles have thus far answered every demand. They are delivered in lots of 100 each, two out of every lot being taken as samples.

Common steel shell are being made by two different processes, one in which they are pressed into shape by means of dies, and the other by the use of electric welding. In the former the shell are made from a cylindrical billet of steel, which is heated and put through a series of dies and presses, which hollow it, draw the sides of this cup-shaped hollow to form the powder chamber, point it, leaving a hole at the apex for the insertion of the fuze; shape the powder chamber inside; and when the operation is finished nothing remains but to cut the screw-thread for the receipt of the fuze. These projectiles can be turned out in any quantities desired, and at a far less cost than the armor-piercing type which are turned by machinery. The method above described has been in use abroad for some years, but the machinery as adopted in this country has undergone considerable change from the original.

The Wheeler-Sterling Shell.—A new armor-piercing steel shell, named the Wheeler-Sterling, and hardened by a process that is at present kept a secret, has recently given such excellent results that a number of the projectiles are being made for naval use. A 6-in. shell, weighing 100 lbs., was recently fired through a high-carbon steel armor plate 11¼ in. thick. The shortening after this severe ordeal was but 0·38 in., and the enlargement 0·23 in. The point was not at all distorted, nor was there a scratch to mar the surface from point to base. This is the first American armor-piercing shell made after an American patent and process, and the result is quite remarkable.

Rapid-fire Projectiles.—The projectiles for rapid-fire artillery, besides being made by the well-known methods of making shell and shrapnel, are now made also by the electric welding process. Iron tubing is cut in suitable lengths, and to this are welded steel heads and bases. Experiments on the proving ground with projectiles of this type have proved them to be well adapted to the purpose; and it is now thought that the larger-calibered shell for ordinary service can be made by the same method. The rapidity and comparative cheapness with which shells made in this way can be turned out recommend the process, which, at present, bids fair to displace all other methods of manufacturing ordinary shell and shrapnel for quick-fire guns. (See WELDING, ELECTRIC.)

Hotchkiss Projectiles.—The Hotchkiss guns are furnished with ammunition made especially for their guns, and it is of three kinds: Cast-iron shell, steel shell, and case-shot. The two former have the same general appearance, and are of the cylindrical ogival type;

together, and backed by oak beams; the charge of explosive was 10 lbs. Ten shots were fired without accident of any kind, and without damage to the gun, the target being completely destroyed by one of the shots.

In 1883, in Germany, a patent was obtained for the construction of a shell to be charged with high explosive, but nothing in the way of experiments was done with the projectile, which was of special construction, and in 1885 a patent was secured for a new process of loading, which could be applied to shell of service pattern. The wet gun-cotton used in this is in the form of prismatic grains, made by cutting up the ordinary compressed disks, and to the charge of wet are added about 200 grams of dry cotton. Space being reserved for the fuze and detonator, melted paraffine is poured over the charge, filling in all its interstices, and, as it cools, forms the charge into a solid mass. Over 200 shell have been fired from an 8.8-cmt. gun without accident, and with complete explosion. Charges of 16 kilograms have been successfully fired from the 15-cmt., and the experiments have since extended to the 28-cmt. mortar. In March, 1888, a 98-kilogram projectile, loaded with gun-cotton and 22 kilograms of powder, was fired from a 21-cmt. Krupp gun. The shell perforated a 12-cmt. compound plate, its 60 cmts. of oak backing, and only burst when it entered an earthen wall at the rear of the target. (See ARMOR; GUN, PNEUMATIC; ORDNANCE, and TORPEDOES.)

Projectiles, Dynamite: see Torpedo.

Propellor: see Engines, Marine.

Pug Mill: see Clay-working Machinery.

PULVERIZERS AND HARROWS. The "pulverizers" constitute connecting-links between the plow and the harrow, and are, indeed, loosely termed harrows; but the action of those with obliquely revolving disks cuts and turns the earth after the manner of the ordinary plow, rather than by raking and scratching it like the harrow proper. The tendency of the revolving-disk "harrow" to encroach on the province of the common breast plow is illustrated by Clark's cutaway disk machine, Fig. 1, which cuts a furrow 40 in. wide and may be run as much as 7 in. deep. It lifts the soil, inverts it, and effectually aërates it. Each of the revolving members is a 24-in. notched disk, dished, and sharpened at the edges, and behind each is suspended a spring-steel moldboard to turn each furrow or cut. Stationary cleaning-knives are added, to scrape any adhering dirt from the disks. A sharp revolving disk land-side precedes each of the notched disks which act as shares. The land-sides do also the work of coulters. A long beam is used, supported at its front end by a 16-in. caster. The plow-heads are supported and gauged by two 24-in. carrier-wheels on a hinged axle governed by a hand lever at the right. The depth of cut of the land-sides is governed by a hand lever on the beam. The lever at the left adjusts the moldboards. The original disk-harrow was furnished simply with a gang of revolving circular dished disks.

FIG. 1.—Cutaway disk pulverizer.

The change of the form of the disks, in the implement under consideration, by cutting away portions at regular intervals so as to leave merely the five or six spade-like blades on each rolling member, has given this class of machine a new impulse of usefulness. Thus made, the blades "scour" better than before in all soils, but are comparatively free from the fault of trailing the soil into ridges, and leaving a dead-furrow or gulley at the center line of travel or the two outer edges, according as the disks are set on an inward or outward gather. The implement is suitable for stubble-plowing and all free-working soils, also hard adobe and clay, but not for stiff sod or very sticky soils. It does not need the heavy weighting required by the solid disk machines, especially on sod lands, fields that have been plowed some months previously, or corn, wheat, or other grain-stubble lands. Four horses are advantageously used. Where this class of machine is used on such land the tilth is better than that of the ordinary plow, and consumes far less time. The cutting edge of a round disk of the customary size is some 50 in., and some 50 ft. of cutting edge must therefore be pressed into the earth at each revolution; while the "cutaway" penetrates the earth with only some 22 ft. of cutting edge, and, therefore, with considerably greater ease. In working say 4 in. deep, each circular disk must have an incisory bearing of some 15 in. per revolution, making 15 ft. of incisory bearing for a twelve-disk machine; but the "cutaway" machine, with the same number of disks and depth of work, has less than 8 ft. of incisory bearing; this diminishes the draft, and yet the disks, by their troweling action, chop the soil into finer fragments. In the Clark cutaway pulverizer, six shovel-blades enter the earth at each revolution of each member, making nearly a quarter turn to stir the earth laterally four inches, crumbling it quite finely. Clark's disk is shown separately in Fig. 2.

FIG. 2.—Cutaway disk.

ing the implement from a stirring to a smoothing harrow, or causing the removal of any gathered trash from the teeth.

Another form of the same class of lever-harrows is shown in Fig. 6, and is strongly made of pipe passing loosely through transverse flat girts, each piece of pipe being connected by an arm pivoted to a horizontal bar, in turn pivoted to the hand lever for adjusting the pitch of the teeth. A lever-harrow by the Ray Implement Co., shown in Fig. 7, has a bearing

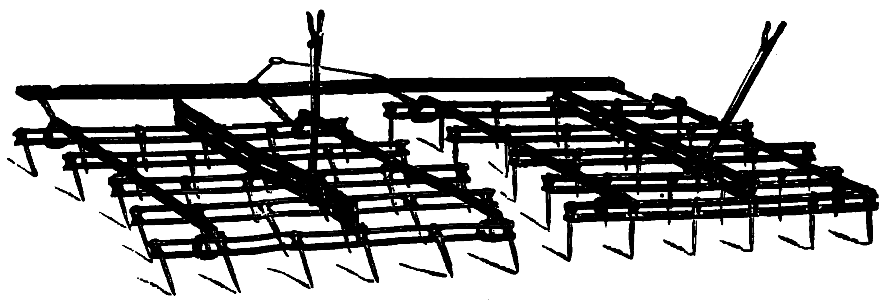


FIG. 7.—The Ray harrow.

shoe at the corner of each section. In transporting this harrow, when it is not desired to operate it, the teeth are thrown back horizontally by the lever, and the corner shoes take the ground as runners. The H. P. Deuscher Co. makes a harrow with sledge runners so arranged as to carry the implement folded and reversed when transporting it not in use. The class of harrows represented by the Kalamazoo spring-tooth harrow (Fig. 8) is not only adapted by the yielding teeth to land that is obstructed by earth-fast stones and other objects, but, owing to the vibratory action of the helix spring-teeth, pulverizes the soil thoroughly, shakes it up and leaves the dirt in a loose condition, shaking out weeds and grass upon the surface, leaving them exposed to the sun to wilt and die. In operation the flattened frame pieces hold down the sods and clods, while the teeth cut deeply through instead of rolling them up. Each tooth has a bead punched up near the heel, which matches a cast-iron socket on the harrow frame. The socket is made with a rib which matches a slot in the harrow frame, and has side flanges to prevent the tooth from swinging to either side. The tooth is held to the socket by a steel clip. The same class of harrow is sometimes iron-plated on the bottom surface of the frame to promote durability, and sometimes made with the frame entirely of iron or steel, corrugated longitudinally to render it rigid. The teeth are also sometimes made with the heel prolonged and continuing the normal curve, so that as the points wear away the depth of cut can be maintained, and the service of the teeth increased by changing the point of attachment nearer to the extremity of the heel as occasion may require. Fig. 9 is the Hoosier pressure-harrow, with a hand lever attached to a rock-shaft having a series of arms controlling the depth of cut by means of connecting rods. The teeth are fitted with springs at the heels, permitting them to yield to avoid breakage. By removing or folding up the middle tooth, the harrow is used as a corn cultivator, the dragbar support being high enough to pass over the growing corn. Fig. 10 exhibits the Hench & Dromgold method of securing the flat class of spring-tooth on a steel-frame harrow. The tooth is riveted to a malleable iron hub with ratcheted sides, and a bolt passes through the frame pieces of the harrow, and two circular plates with crown ratchets to engage the hub ratchets As the tooth wears away and shortens at the point, the hubs may be correspondingly rotated by

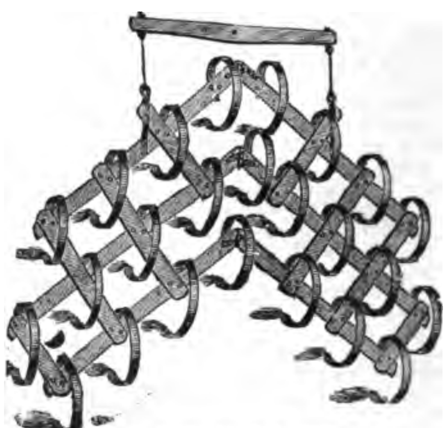


FIG. 8.—Spring-tooth harrow.

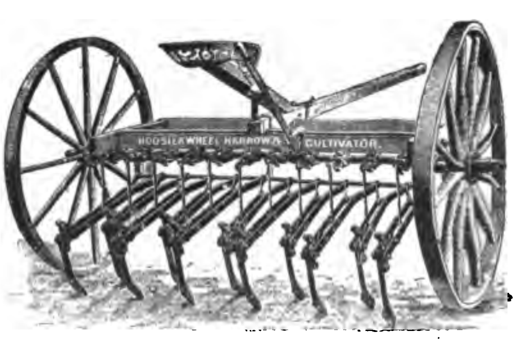


FIG. 9.—The Hoosier pressure-harrow.

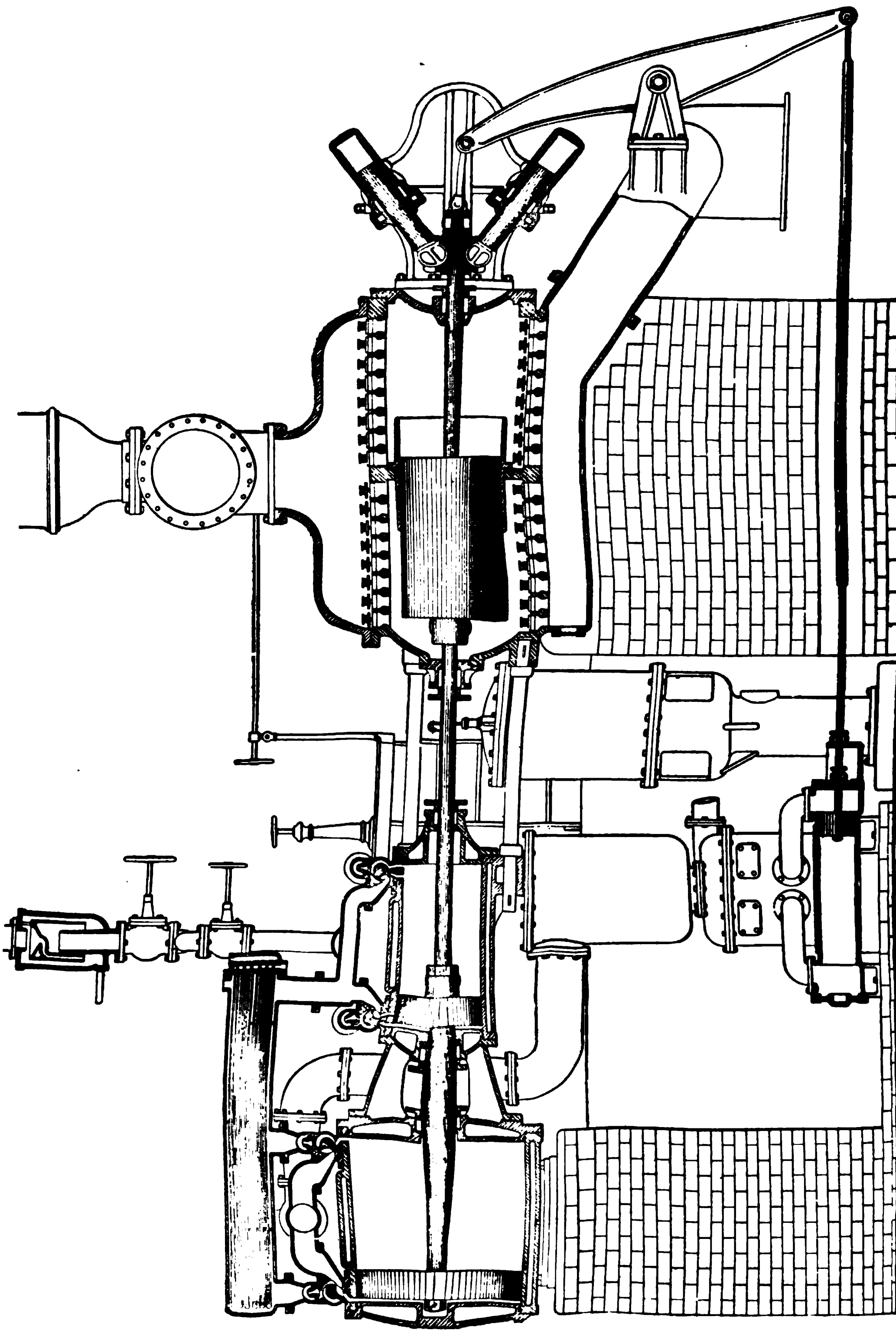


FIG. 1.—The Worthington high-duty pumping engine. (Sectional view.)

being directly under them, and 60 in. diameter. The pump plungers are 27 in. diameter, and the stroke is 48 in. The valves are of the Corliss type, with a cut-off valve placed over

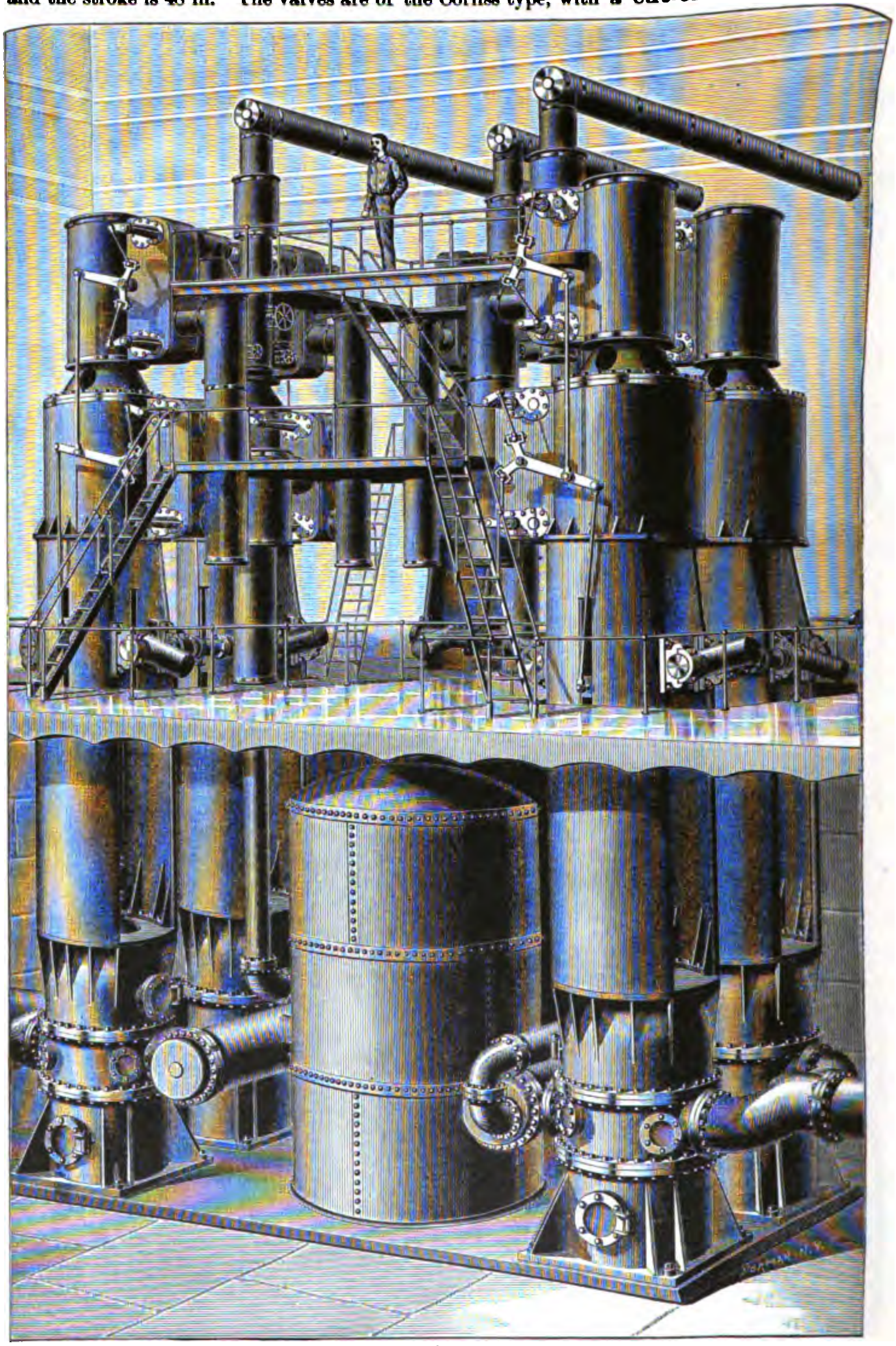


FIG. 2.—Worthington compound direct-acting pumping-engines.

them, but are not, of course, worked by the Corliss valve motion, since the point of cut-off is fixed. The compensating cylinders are, on these engines, placed on the frame between the

:tion of tubes, 7·18 sq. ft. Total area of chimney flue, 8·33
ace to grate surface, 43.42. Ratio of grate surface to area
grate surface to area of chimney flue, 7·92.
es are obtained from the records of the test: Mean steam

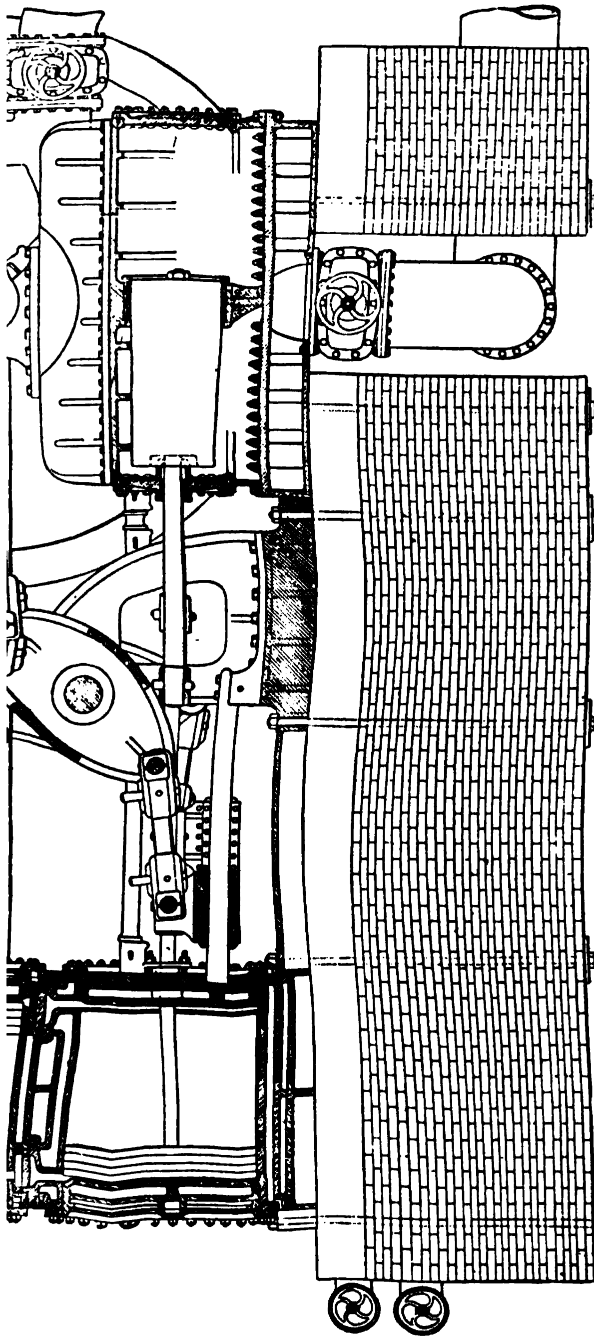


FIG. 3.—Sectional elevation, Gaskill horizontal pumping-engine.

·05 lbs. Mean steam pressure at engine, per gauge, 78·01
ackets, per gauge, 70·075 lbs. Mean water pressure. per
pressure on pumps, corrected, 103·735 lbs. Mean vacuum,
ı. Mean vacuum, per gauge on engine, 27·87 in. Mean
5° F. Mean volume of water, at 51°, passing the meter per

of these holes will readily be seen in that they complete the channel to the full bottom, without what is usually known as "running off," and without requiring labor at the end of the cut. After the channel is completed to the full depth, full length of the bar (which is about 10 ft.), the whole machine is barred along ther and one hole is put in, the channel being continued up to this hole. The legs the bar is very much facilitated by shoes fastened on each leg. The legs so as to take all angles and to adapt themselves to any irregularity of the quarry. The machine is shown doing vertical channeling in Fig. 5, and by may be applied to do horizontal channeling, in Fig. 6. Horizontal channeling work where vertical channeling is not sufficient to remove the blocks. It more expensive to cut a channel horizontally than to cut it vertically, because channeling we have the benefit of the weight and inertia of the cutting tools.

In adapting the bar channeler to the making of channels upon inclined floors weight is employed, which hangs over a pulley at the top of an upright piece

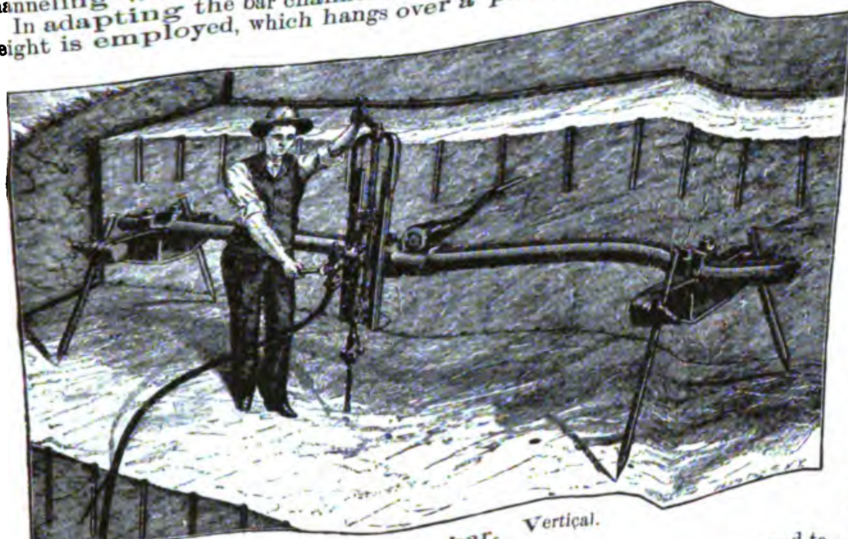


Fig. 7.—Plug-and-feather bar. Vertical.

ing a line of holes for plug-and-feather work. This bar is also used to a limited extent for drilling holes for blasting purposes. Several forms of bars are in use, some of them being made of angle iron, but the simplest is that shown in the cut, which is made of a piece of extra heavy wrought-iron pipe, turned in a lathe and provided with a rack riveted to it running longitudinally. The bar is mounted upon end pieces, which are in turn provided with swivel connections in which are inserted four legs or supports. These legs are adjustable in length and in angle, so that the bar may be placed on irregular floors. A rock drill is mounted upon the bar with a carriage which is provided with a pinion and crank. The operator by turning the crank moves the drill to any point along the bar.

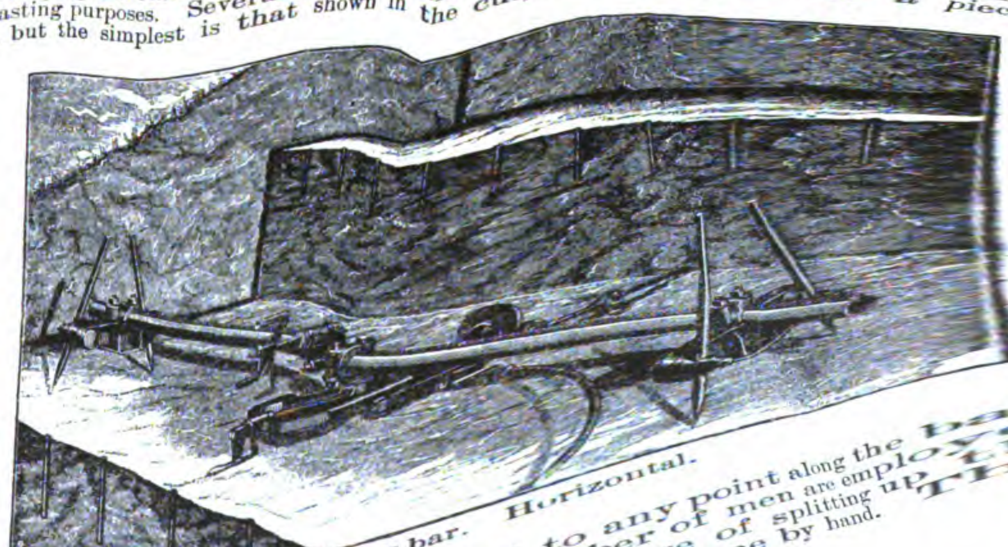


Fig. 8.—Plug-and-feather bar. Horizontal.

In quarries and in stone-yards it is frequently noticed that a number of men are employed to drill small holes, from 3 to 6 in. deep, in large blocks, for the purpose of splitting up the blocks into sizes for the market. In granite, a great deal of this work is done by hand. This can be done by machinery about ten times as fast, and at much less expense.

bench. In marble quarries, where it is desired to separate the "stock," thes
on the line of the "riving bed." or with the dip of the marble. The ma
the improved Ingersoll "Eclipse" rock drill, mounted upon and made to
dinally a standard or post, which is fixed through trunnions at its lower
bed-piece or car, and which is made to swing in a vertical plane fron
position to a nearly horizontal one. The drill is pivoted to a saddle, which i
on the standard
chain, which pas
at the top and
which is turned
saddle is fixed at
on the standard
gib, which is tig
by the throwing
handle in the
The car moves
without a track
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about 6 ft.
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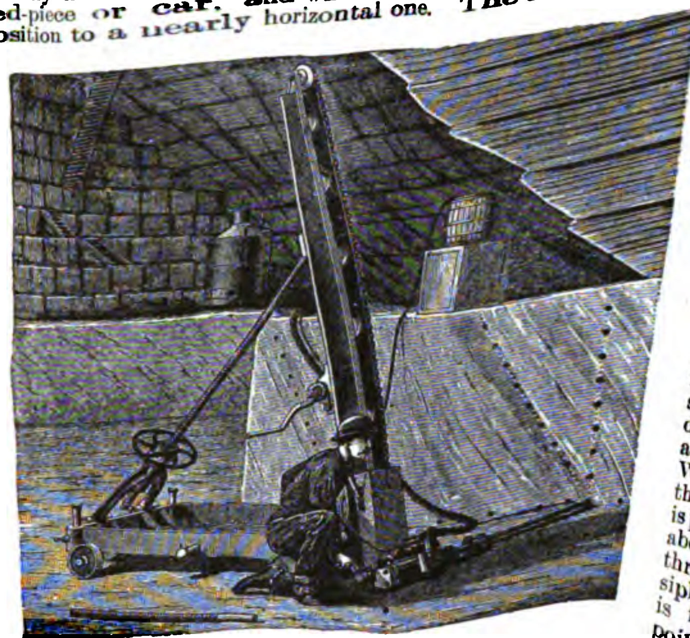


Fig. 12.—Gadding machine.

few inches from the orifice. Where the bench is 6 ft. or
tie-rod or brace while putting in the top holes. This rod
the standard at one end, and is driven into the cut beyond
thus resist the thrust of the drill. The record of this machine
2-ft. holes in a day of ten hours. It requires twenty seconds
and place the drill in position to begin another. The machine will put in a hole 3 ft. in depth without stopping.

The Diamond Gadding Machine is represented in Fig. 13. The machine is placed upon a platform on trucks arranged to run upon a track. When adjusted for work it may be braced by the pointed legs shown. The boring apparatus is attached by a swivel to a perpendicular guide-bar. This guide-bar is secured to the boiler behind it, which forms the main support of the machine. Upon the guide-bar the boring apparatus may be raised or lowered at pleasure, for the purpose of boring a series of holes in a perpendicular line if desired. Upon the swivel the boring apparatus may be turned, so as to bore in any direction within the plane of the swivel-plate. The illustration shows the drill-rod or spindle placed near the base of the machine, and so as to bore horizontally. At one end of the spindle is the drill-head, armed with carbons, and supplied with small apertures or outlets for water. At the other end of the spindle is attached a hose for supplying water to the drill-head. A rapid revolving movement is communicated to the drill-spindle by the gears shown. The speed and feed movement may be regulated by the operator with reference to the hardness or softness, coarseness or fineness, of the material to be bored; and the feed movement may be instantly reversed at pleasure.

Channeling-machine Bits.—All percussive channeling machines carry a gang of cutters bolted together, and in every case the bits or points are chisel-shaped, some of them having straight edges and others diagonal ones. The cutting tools are in the shape of gangs, instead of being in solid bars, bec
handled and transported to the blacksmith shop, and because the l

Fig. 1

bench, as may be regulated by the thickness, strength, and character of the rock. is so good a judge of this as the quarry foreman, who has used and studied the Knox system in his quarry. Great care should be taken to drill the holes in a straight line. In sandstone of medi ness these holes may be situated 10 ft.. 12 ft. apart. If the bed is a tight one—that it is not entirely free at the bottom—the h be run entirely through the sheet and but with an open free bed holes of less suffice.

FIG. 15.—Knox reamer.

The reamer should now be used and hand. Several devices have been appli drills for reaming the hole by machinery while drilling—that is, efforts have to combine the drill and the reamer. Such efforts have met with only partial su perfect alignment of the reamer is so important that where power is used this to be neglected. It is also a well-known fact that the process of reaming by hand is not a difficult or a slow one. The drilling of the hole requires the greatest amount of work. After this has been done it is a simple matter to cut the V-shaped grooves. The reamer should be applied at the center of the hole—that is, the grooves should be cut on the axis or full diameter of the hole. The gauge of the reamer should be at least $1\frac{1}{2}$ times the diameter of the hole. While driving the reamer great care should be taken that it does not twist, as the break may thereby be deflected. Ream until you can do so no further—that is, ream to the full depth of the hole. The hole is now ready for charging. First insert the powder, which should be a low grade of explo- sive. Do not use dynamite. Black powder, Judson powder, or other explo- sives which act slowly, are preferable. No definite rule can be laid down as to the amount of powder to be used, but it is well to bear in mind that as little powder should be used as possible. The powder must, of course, be provided with a fuse. or, preferably, a fulminating cap. It is well to insert the cap about the middle of the cartridge.

After the charge the usual thing to do is to insert tamping, but in the Knox hole the tamping should not be put directly upon the powder, but an air space should be left, as shown at B, Fig. 16. The best way to tamp, leaving an air space, is, first to insert a wad, which may be of oakum, hay, grass, paper, or other similar material. The tamping should be placed from 6 to 12 in. below the mouth of the hole. In some kinds of stone a less distance will suffice, and it is well to bear in mind that as much air space as practicable should intervene between the explosive and the tamping. Care should be observed in tamping not to destroy the wires which connect with the explo- sive, but the tamping should be made secure so that it will not blow out. The hole ready for blasting. If several holes are used on a line they should be connected and blasted simultaneously. The effect of the blast is to make a vertical seam con the holes, and the entire mass of rock is sheared several inches or more.

The philosophy of the Knox blast is simple, though a matter of some dispute. M gives the following explanation:

"The two surfaces, a and b, Fig. 14, being of equal area, must receive an equal an the force generated by the conversion of the explosive into gas. These surfaces being and presenting no angle between the points, A and B, furnish no starting point for a f but at these points the lines meet at a sharp angle, including between them a wedg space. The gas acting equally in all directions from the center is forced into the tv site wedge-shaped spaces, and the impact being instantaneous, the effect is precisely to that of two solid wedges driven from the center by a force equally prompt and er All rocks possess the property of elasticity in a greater or less degree, and this p being excited to the point of rupture at the points A and B, the gas enters the crack rock is split in a straight line, simply because under the circumstances it cannot s other way."

It is doubtless true that, notwithstanding the greater area of pressure in a Knox h break would not invariably follow the prescribed line but for the V-shaped groove virtually starts it. A bolt, when strained, will break in the thread, whether thi smallest section or not, because the thread is a starting point for the break. A rod is broken with a slight jar, provided a groove has been filed in its surface. Numero instances might be cited to prove the value of the groove. Elasticity in rock is a pro feature, which varies to a greater or less extent, but it is always more or less pres sandstone has recently been found which possesses the property of elasticity to suc tent that it may be bent like a piece of steel. When a blast is made in the Knox stone is under high tension, and, being elastic, it will naturally pull apart on such weakness as grooves, especially when they are made, as is usually the case in the K tem, in a direction at right angles with the lines of least resistance.

Our previous illustration of a break by the Knox system was its simplest and be cation. An identical case would be one where a large and loose block of stone was into smaller ones by one or more Knox holes. But those who use this system do no it to such cases alone. Horizontal holes are frequently put in, and artificial beds

this slide is a wedge-shaped block. The wedge actuates two jaws hor and close according to the direction in which the slide is moved, closir moved upward. These jaws have pieces of soft cast-iron placed in the removed when worn out. These pieces of iron are of proper shape and the rope when they are closed over it. On both sides of these jaws and are four small pulleys. These pulleys are held by means of rubber cr in advance of the jaws to keep the rope off from the jaws and at the sa rope fairly between them, allowing it to travel freely between the ja separated, without touching them. When it is required to grip the drawn up by means of the small screw and hand wheel, before descri at the lower end closes the jaws over the rope, at the same time forcing b sheaves onto the rubber cushions. The shank, containing the slide, et retained in cast-iron slides attached to the body of the car, and a wro having a large nut at its upper end, in which the large hollow screw raised and lowered bodily through the opening in the tube from above street to the rope in the tube by means of the hand-wheel and nut w hollow screw referred to. The grip is secured to a skeleton or traction-car called a dummy. The dummy is coupled to the passenger cars at the top, and uncoupled at the bottom of the incline and *vice versa*. At first the connection between the dummy and car was made by means of spiral springs, to prevent any jar in starting up; but this was soon found unnecessary. The arrangements made at the bottom of the incline for keeping the rope at the proper tension, and taking up the slack, prevent any noticeable jar in starting. As before stated, the rope is constantly in motion, running between sheaves placed in the tube. The slot of the tube is on one side of a vertical line drawn through the center of the tube; and referring to Fig. 3 it will be seen that the foot of the gripping attachment projects on one side, giving it an L-shape, enabling the jaws to pass under and over the rope sheaves in tube. In order to stop the car, the jaws of the gripping attachment are slightly opened; when they release the rope the guide sheaves take it, and the car stops. In another form of grip used on the Sutter Street Railroad, San Francisco, the motion of the gripping jaws is vertical, instead of horizontal, and the rope is taken up and released at the side. In order to run upon or off the rope at the termini of the road, the track and slot diverge from or converge to the line of the rope. Levers are used for operating the jaws instead of the screw.

The particulars concerning a number of cable roads are given in the table appended to this article. The construction of the Market Street Railroad in San Francisco possesses many points of interest. The foundation for the road-bed and track rests upon concrete piers extending to a depth of 10 ft. or more below the surface of the street. These piers have a width of 5 ft., and are 16 in. thick, and are placed about 9 ft. apart. The track and tube of this road are made into a s by connecting the rails and slot-irons by yokes, and uniting the whol crete. The main tie or yoke connecting the opposite rails is formed o bent in proper shape head down. It embraces th ened to the ends suitable chairs or plates, to which From the lower part of the curved yoke extend for the slot-irons. The lower ends of these are to form the necessary width for the tube. Ti supports with the main yokes through the chai slot-irons, and yoke are then all connected rig Car and dummy are united in one vehicle, 34 ft Tl supported on two four-wheel pivoted trucks. the track-brake, which is between the wheels on tion there are the usual wheel-brakes. The forw grip and hand levers. A rod connects the roc brakes with the hand lever on the forward truck. b

FIG. 3.—Grip.

The grip in use on this road is worked formed of two frames, one sliding inside the is secured to the grip-bar on the forward truck the lower jaw, while the inner frame, which slides up and down up ries the upper jaw, the quadrant, the operating lever, and adjusting m in place by guide plates extending across the inside frame, and between frame carrying the jaws passes through the slot directly down alongs offset. The grip-bar, on which these parts are mounted, is secured frame on the running gear or truck, and not on the car itself. The c be mounted on springs without any of the spring motion being imp through it to the cable. In the way in which this grip is arranged all t out of order are accessible, and it is not necessary to provide pits in wh When the car is at a standstill the cable passes along over the chill

the strain, and the tracks are also carried on double posts at these points, as well as at approaches, as a precautionary measure.

The entire length of the straight surface tracks of the cable line is 99,328 ft.; of curves, 2,010 viaducts, 4,250 ft.; of bridges, 2,124 ft.; and of the pits, 562 ft.; making a total of 108,274 track, or rather over 20½ miles, and the construction 1,444 tons of track and slot rails, and 2,919 tons sleepers.

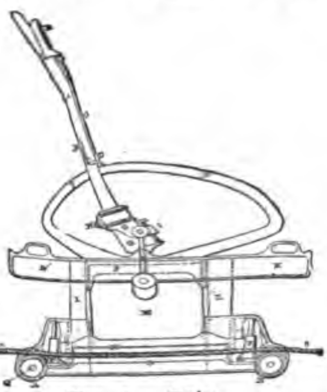


FIG. 5.—Grip.

As already stated, there are three power stations on tem, all similar in arrangement. The engines are pound, the high-pressure cylinder being 26 in. in dia and the low-pressure 42 in. in diameter; the stroke is They are intended to develop 700 horse-power at a 75 revolutions per minute. The high and low-pressure ders are set side by side, and the distance between cen ft.; the total length of built-up crank shaft is ½ in. The fly-wheel is 14 ft. in diameter, with rim of 14 in. 18 in. deep, and weighs 36,000 lbs. The first driving the winding machinery is 18 ft. 2¼ in. long, with two at the ends, and one at the center between the dri pulleys. In the bosses of these pulleys the shaft is 16 in. in diameter. The rope wheels, which are two ber, are 6 ft. 1⅞ in. pitch diameter; they are made and are each grooved for fourteen 2 in. cotton ropes, of the engines being transmitted to the driven wheels by a system of en transmission instead of by gearing. The large or driven rope wheels on rope shaft are 25 ft. in diameter, built up of ten segments each, with a hollow boss in one piece, and ten hollow arms of elliptical section. The shaft which carries these wheels is 16 ft. 1½ in. long, the diameter in the boss of the wheels being 19½ in. This shaft is coupled at each end to the winding shafts, which are 11 ft. 10¼ in. long, 17 in. in diameter in the center, and 15 in. at the bosses of the overhung rope drums. These latter are mounted on each end of the winding shaft, and each has two grooves for 2-in. cotton ropes, their diameter measured to the center of the rope being 15 ft. They drive two other rope wheels or "idlers," which are mounted on their own shaft. These idlers are of 1 in. less diameter than the driving rope drums, and the purpose of this is always to keep the cotton ropes taut, so that the cable itself may not have to perform any of the work of rotating the idler wheels, the necessary amount of slip required, as these slightly smaller wheels gain on the drivers, being provided for in the clutches with which the cable drums are driven. The cable drums are loose on the extended bosses of the rope wheels, and are held to these wheels by friction disks, which are tightened by eight screws and hand wheels in each drum. The cable drums on the winding shaft 13 ft. in diameter, with five grooves each for 1¼ in. cable, and those on the driven shaft of the same diameter, but with four grooves in each. The cable speed corresponding to revolutions per minute of the engines, is 8½ miles an hour.

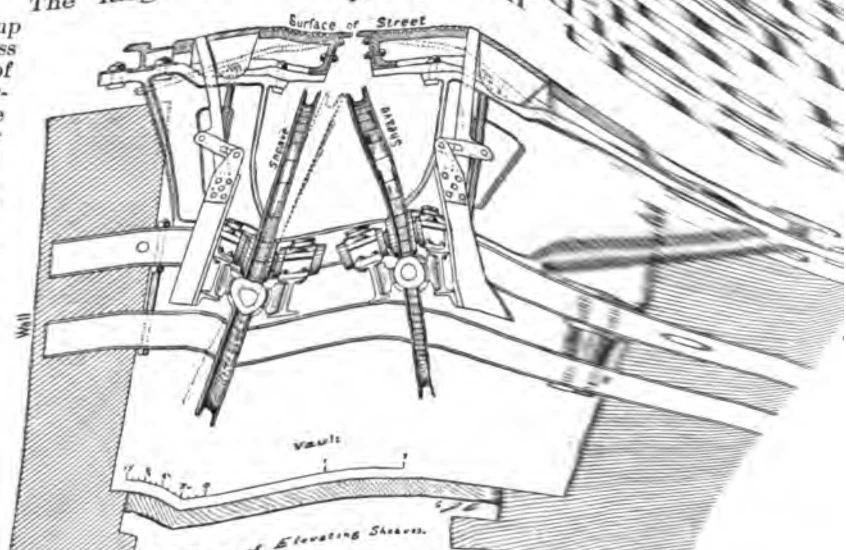


FIG. 6.—Duplicate cable railroad.

The Miller or American System of Cable Railways is constructed by the American Cable Railway Co. of New York, and is based upon the designs of Mr. D. J. Miller. The principal characteristic of this system is the use of duplicate cables laid parallel to one another through the tube on either side of the slot, and so arranged at the driving station that if one cable or its machinery should become disabled, the second rope can be brought into immediate use. Each system is entirely independent of the other by reason of this duplication. The following advantages are claimed: Besides operating the road uninterruptedly, the motive power more durable, as ample time can be allowed for close inspection and needed repairs, there prolonging the life of both cable and machinery. Roads operated by duplicate cables run steadily twenty-four hours per day, while with but one rope this is not possible, as some time must be devoted to examination and repairs. This system is in use in New York City on the Tenth Avenue road, where the cables are worked independently in the following manner:

At the point where the cable is first carried into the conduit, sheaves 4 ft. in diameter

drums are provided, but only one set is used at a time. The other stands idle, and its lies on the ties alongside the pulleys on which the live cable runs. In the street roads, duplicate cables, duplicate sets of carrying pulleys are provided, because the men cann down into the conduit to put the spare cable on the pulleys, and throw the other one off a change is made. This simple process of changing cables can be easily carried out bridge, however, as there is no cable conduit.

In all the New York cable roads the cable is driven by being wrapped around two drums, placed in nearly the same perpendicular plane, with their axes about 20 ft. apart. is a curious fact that though the same cable runs around these two drums, they do not at the same speed. In the bridge cable machinery one drum lags a revolution an hind the other. This is supposed by some to be due to the fact that the cable slips more upon one drum than upon the other. Some engineers think it is simply due unequal wearing of the drums, whereby one becomes of less diameter than the other. much as it is always the same member of the pair that lags, the first hypothesis wou nearer the truth. In the bridge machinery this is provided for by a system of gearing, by which the two drums are geared to the driving shaft, much as two hitched to a wagon by an equalizing bar.

From the opening of the bridge railway, September 24, 1883, to November inclusive, 220,487,283 passengers were carried. Of the delays during the past year cent. were occasioned by a failure or defect in some of the several parts of the cable machinery, and the other 46 per cent. by causes common to ordinary railroad trans The grip mechanism failing to act was the cause of but thirty delays, amoun gether to 2 hours and 57¼ minutes out of the 7,300 hours during which the cable was

Six cables have been used on the bridge, the two now in operation, and the four been worn out and thrown away. The following table gives the statistics in regard

Cable.	Condition.	Term of service. Days.	Years.	Miles hauled.	Ton miles hauled.
No. 1..........	Worn out.	1,140	3·123	228,329	22,142,706
No. 2..........	Worn out.	607	1·636	120,282	25,492,892
No. 3..........	Worn out.	393	1·077	82,099	20,395,073
No. 4..........	Worn out.	356¼	0·977	74,111	18,923,467
No. 5..........	In use.	267¼	0·758	58,881	16,746,912
No. 6..........	In use.	187	0·512	39,980	12,506,418

The last column gives the average strain on the cable during use, and of course the ton miles are obtained by multiplying the weight pulled by the number of miles through which it was pulled. As the speed of the cable is constant, and also the distance traveled by each car between taking up and releasing the cable, it is evident that the number of car trips performed on any one cable will vary as the figures in the ton-mile column. These were nearly constant. Cable No. 1, which ran the extraordinary distance of 228,329 miles, was gripped and released only a few more times than cable No. 4, which ran 74,000 miles—about the average life of a cable on a street railway. So it may be that the principal factor in the destruction of a cable is the pinching, crushing action of the grip jaws closing on it, and not its sliding through the grip or turning around corners. Of course this pinching action of the bridge grip is greater than that of the ordinary street-car kind, for the bridge cars are heavier, and the area of contact, being merely that of the point of tangency between a circle and a straight line, is less.

The Broadway Cable Road, of New York City.—At the present time of writing, a road 5.17 miles long is being built in New York City, extending from the Battery to Fifty-ninth Street. The track is set upon cast-iron yokes, which also hold the slot rails and encircle the ends of the sections of the sheet steel cable conduit. The yokes are 27½ in. high to top of lugs, and 23 in. to rail seat. The distance between the yokes is 4 ft. 6 in. They rest upon separate foundations of concrete, which are 45 in. long, 18 in. wide, and 6 in. deep. The conduit in which the cable runs is formed of sheet steel sections, with a backing of concrete. The pits in which the carrier sheaves are located are 42 in. deep and 31½ feet apart. The slot rail is formed of two like but oppositely arranged Z-shaped parts, leaving between them a groove, through which the grip extends from the car down into the conduit, where it engages the cable. The slot rails are braced at frequent intervals by wrought-iron rods passing through the tram rails and through the slot rails. The entire construction is designed to be permanent. The yokes which support the tracks weigh about 550 lbs. each; the tram rails weigh 91 lbs. per yard, and the slot rails weigh 67 lbs. per yard. Each was specially designed for this work. The gauge of the track is 4 ft. 8½ in., and the distance from center to center of the tracks below Thirty-fifth Street is 9 ft.; above Thirty-fifth Street it is 10 ft. The diameter of the cables will be 1¼ in.; the cable drums will be 12 ft. in diameter; the large rope-driving drums will be 32 ft. in diameter, and the small ones 10 ft. and 7 ft. 6 in. The Corliss engines driving these drums will have cylinders 36 and 38 in. in diameter, with a piston stroke of 60 in.

The following table of information relating to cable roads has been published by the Pacific Cable Railway Co.

RAILROAD CARS. VESTIBULE CARS.—*The Pullman Vestibule* provides a continuous connection between contiguous ends of passenger railway cars, forming an entirely closed passageway, preferably of the width of the platforms, and serving at the same time as a vestibule for entrance and exit to the respective ends of adjoining cars. The connection is made of flexible or pliable material, so as to constitute a loose or flexible joint that will permit of sufficient movement of each unit car in travel. Fig. 1 is an isometrical perspective view of the end of a car, and Fig. 2 is a perspective view, showing portions of the platform, vestibule, and buffer mechanism, and Fig. 3 shows the end of a car. The arch-plate, *a*, forming the open end of the vestibule extension to a railway car when not connected with another car in a train, and which sustains the outer edge of the flexible connection, is mounted upon the buffer-rod, located below the platform of the car. The buffer-spring, *m*, encloses the buffer-rod, which is moved outward by the spring, and inward by the impact of an adjoining car or buffers connected therewith. Upon it is mounted a cross-bar, *l*, in such manner that it can move out and in with the buffer-rod, and at the same time swing upon its center as the evener of a wagon does upon the pole. Two rods, *s s'*, are attached to the cross-bar, *l*, by a sort of ball-and-socket joint in such manner that the cross-bar may change its angle to horizontal lines drawn perpendicular to the length of the car, while the rods, *s s'*, always remain substantially parallel with the sides of the car. These rods cannot practically move in any other direction. They project beyond the outer cross-beam of the car, and are there pivoted to the vertical buffer-plate, *n*. Obviously this buffer-plate on one car can not have its acting face coincident with the two similar buffer-plate on an adjoining car when the two cars are rounding a curve unless it change its angle with reference to a longitudinal line passing through the center of the car, so that it can be at times at right angles to such a line, and at times at various other angles. The support before described not only permits these changes of angular position, and the in-and-out motions of the buffer-bar, but prevents its center from leaving a horizontal longitudinal line passing through the center of the car, to which it is attached, so that the center of the buffer-bar is always, whether projected or shoved in, practically in line with the center or middle of the platform.

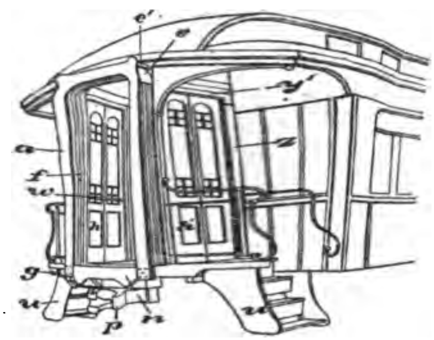


FIG. 1.—Pullman vestibule.

Two cars moving in a train vary the distance between the ends of their respective platforms, and also the angles that one of these ends makes with the other, and there is a gap between the platforms. To close this gap there is applied to each of the buffer-plates before described a *foot-plate*, the inner edge of which rests upon the top of the platform of the car, and slides and turns upon it when the car is in motion. Upon the ends of the buffer-plate is mounted an iron archplate, *a*, which has the same motions as the buffer-plate, and is restrained in the same manner.

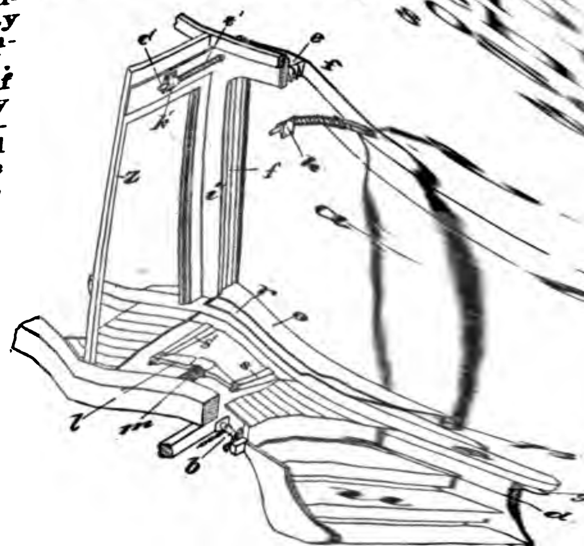


FIG. 2.—Pullman vestibule construction.

When two adjoining cars are coupled, the arch-plates on each car abut one against the other, and they thus abut when the cars are upon straight lines or curves, or are being started, tending to separate, or are stopping, tending to come nearer together. The two arches in adjoining cars therefore make a joint. Each arch-plate has attached to it one edge of a sheet of leather or other flexible material, and at the other edge this is attached to the stanchions. In the spaces between the stanchions, on the same side of the platform are doors, *h h'*.

The upper ends of the arch-plates are supported from the car body by rods, *c c'*. These rods slide in guides or supports, *k k'*, and are forced outward by spiral springs, *t t'*. The guides, *k k'*, are bolted to the framing supported by the stanchions, and the rods, *c c'*, can move in and out together or independently, but can not practically move sidewise or in lines which are not parallel to a line passing centrally and longitudinally through the car. These rods, *c c'*, have the same motions as the rods, *s s'*, below the platform, and as they are pivoted to the arch-plate, the latter is so supported at top that its top can move and the restrained in the same way as the foot-plate, the buffer-plate, and the lower part of the arch-plate.

The Barr Vestibule.—Fig. 4 is a section through the end of the car, showing the face plate and the parallel motion which keeps the plate always parallel with the end of the car.

for its weight will carry a greater load than any bolster of t
body bolster greater carrying capacity, two 4-in. I-beams
channels and the sills. These extend from side bearing

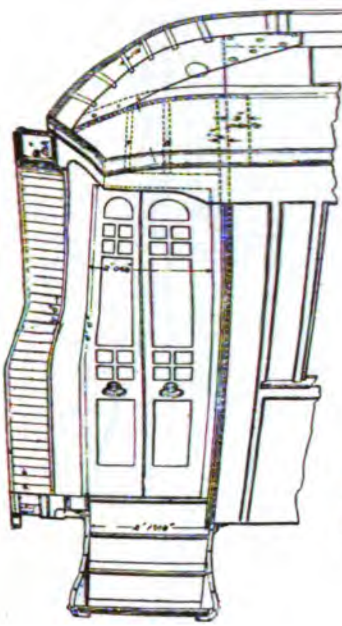


Fig. 4.—Barr vestibule construction.

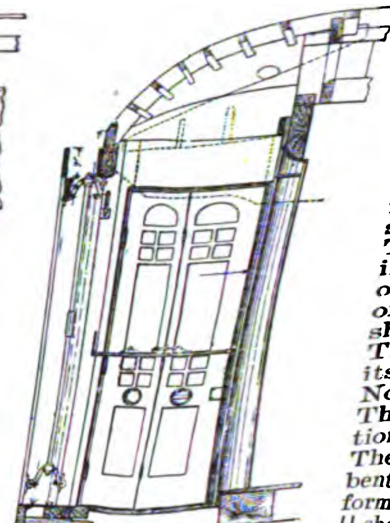


Fig. 5.

Thus deep a are in across tion to also in 4-in. ch posts a U-sectic at top an the sills made in sills, but The inclin iron 3 × 2 of ¾-in. r of steel, in shape with This is pro its weight No. 16 stee The end do tion and m The carline bent to a U form with U-shape of carlines has pose of rece which the c is nailed. out with w outside with

B. W. G. The roof is No. 20 B. W. G. This is the most promisi been constructed in this country. (See *Railroad Gazette*, Septemb

Standard Truck.—The general construction and leading dimensions of the standard truck designed for the N. Y. C. & H. R. Railroad are as follows:

It is a rigid truck, with a 15-in. channel bar having 4-in. flanges, for a sand plank. The bolster is 12 in. wide by 11 in. deep, and is trussed by two 1¼-in. round rods. This bolster, which is intended to carry about 35,000 lbs., has a safe working strength of 86,000, so that the margin of safety is enough. The axles are M. C. B. standard, with 3¾-in. × 7-in. journals. The center plate is of cast-iron.

Car Wheels.—In a paper read before the American Society of Civil Engineers, Mr. P. H. Griffin says:

"The best section of wheel depends largely on the service intended and upon the quality and character of the wheel, but certain lines should be followed irrespective of these two conditions on all steam roads. The strains imposed on a wheel are of two kinds: the first consequent on load carried and speed attained; the second that which results from the use of brakes. The first strain multiplies the second in a definite degree. . . .

"It does not follow at all that good wheels will be made because a pattern of proper section is used. That is the first necessity; the second is the method by which the wheels are made. The manufacture of car wheels is hard, laborious work. One man with a helper will turn out on the average eighteen wheels per day. The work is done almost invariably by the piece, ar finished in ten hours or less. Half of this is given to molding, and th To prepare and finish eighteen molds in five hours necessitates doing th than twenty minutes. The most exacting attention to every detail is n and melting the iron. If not given, it may not always produce danger

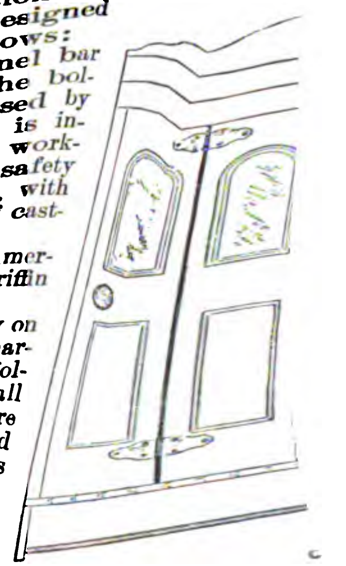


Fig. 6.—The Cowel

ring and an inner chilling ring united to each other by webs of suitable length with air spaces between them. The inner ring, forming the chilling face, is from 1½ to 3 in. more in thickness. It is divided into many perfectly separated segments in the process of casting, by the use of asbestos cores. The cores are formed of two thicknesses of asbestos paper, enclosing a sheet of blotting paper of the proper thickness. In a 33-in. there are more than one hundred of these cores. The segments thus formed are about in width, whilst the kerfs separating them are not more than 1/16 in wide, which is very less than it is possible to produce by sawing, especially through a thickness of more than By this construction the outer ring is prevented from becoming either quickly or in heated by the molten metal of the wheel. It thus retains its original size and shape as a buttress from which the segments must expand inwardly. At the same time, well-known fact that liquid iron expands in solidifying, as water does when it becomes the metal forming the wheel expands outwardly as it becomes solid, or is "chilled" presses firmly against the advancing segments. As these then become more and more by this close contact, the kerfs allow them to expand laterally in the direction of the ference. By careful experiment it has been found that this lateral expansion ment 1 in. in width, when heated to redness, is 1/100 in., so that in the one hundred before described there is ample provision made for this closing in of the circumference out causing any strain upon the chill either to change its shape, to disintegrate its or to break it in two. At the same time these kerfs are so narrow that they make ous ridges, and the treads of the wheels are practically as smooth as if cast in solid

The Boies Steel Car Wheel is built up by two corrugated mild-steel plates bolted hub, and to an internal flange on the steel tire. The tire is shrunk on before being the plates. The inner flanges of the plates are also shrunk on each end of the hub corrugations of the steel plates insure an elastic, in distinction to a rigid, resistance the hub and the tire.

Rolling Car Wheels.—A novel machine for this purpose has been designed by Jones, of Philadelphia (see *Railroad Gazette*, October 9, 1891). A cast-steel car wh or bloom, having the hub near the desired proportions, and the web and rim thick desired in the finished wheel, is placed between three rolls—a movable driven tread two side rolls—one of which operates in sliding bearings but is not driven; the driven rotating in fixed bearings. The movable tread roll in its sliding bearings approach the side rolls during the continuance of the operation. The tread roll to give shape to the tread and flange of the wheel, and is movable by means of pressure to compress, harden, and extend the wheel to any desired diameter supported and revolved by the side rolls. The side rolls operate on, compress, the web of the wheel, assist in revolving the bloom, holding it in position to be by the tread roll. One of these side rolls runs in fixed bearings; the other, which on bearings, moved by means of hydraulic pressure, rolls the web of the wheel. hardens and compresses the metal, moving inward toward the fixed side roll. rolls are of greater diameter than one-half the diameter of the wheel. During the the metal flows outward from the center toward the rim; at the same time the wheel is elongated and increased in diameter by pressure being given to the tread metal of the hub is rolled and hardened by means of the coöperation of the side the steadying rolls. This is done by holding the side rolls on fixed bearings while them, and bringing pressure to bear upon them through the bloom from the steadying rolls.

Rubber-cushioned Car Wheels.—A novel form of car wheel has a rubber cushion between the tire and the wheel center, by which construction it is claimed that the vibrations resulting from uneven track and other causes are prevented (*Railroad Gazette*, September 4, 1891).

Wrought-iron Wheel Centers have been much used at the Baldwin Locomotive Works. The wheels are drop-forged or swaged from parts previously rough shaped, which are not only swaged or die-forged, but are simultaneously welded together.

The Lappin Brake-shoe is made by casting a shoe in a solid piece, from metal combining both strength and softness to a high degree, and with intervening chilled and soft sections of the same metal. The chilled sections radiate into, and mingle with, the soft metal composing the body of the shoe and leave no clearly defined dividing line to form a cutting edge. The soft sections project about 3/16 of an inch on the face of the shoe.

A series of valuable practical lectures on car wheels was delivered by Mr. R. W. Hunt in the Sibley College Course, Cornell University, 1890 (see *Scientific American Supplement* of that year).

RAILROAD, ELECTRIC. Some experiments were tried in 1867, at Berlin, in electric railways, by Dr. Werner Siemens, but the work was abandoned because the armature of the Siemens machine then used became heated too quickly and too greatly to be of practical service. Under conditions of more promise, the experiments were resumed by Siemens & Halske in 1879, and carried to a successful issue. The first permanent undertaking executed on the Siemens system was the line between Lichterfelde and the Central Cadetten Anstalt, near Berlin. This installation differed somewhat in detail from the first attempts in the manner in which the current was led; for whereas in the latter a third central rail was used, the former employed only the two existing rails, one as a lead, and the other as a return circuit.

With the advancing efficiency of the dynamo as a generator, or as a consumer of current, and with the success of the Paris Exposition in 1881, came a revival of interest in the subject of electric railways in America, as elsewhere. At the Chicago Railway Exposition, in 1883, Mr. Field exhibited the electric locomotive named "The Judge." The track

ı-pressure side; *B*, the outlet or low-pressure side. The operation of this valve is as follows: The small regulator valve, *I*, has been set to close at, say, 40 lbs.; relief valve, *O*, to open at as nearly as possible the same pressure. This can be readily adjusted when the valve is working. It is preferable to have relief valve, *O*, open a little in advance of the closing of the regulating valve, as this keeps a circulation constantly through the chamber, *K*, and valve, *I* and *O*. This maintains a very even pressure in the chamber, *K*. The pressure in chamber, *K*, determines the pressure on outlet side of valve, *B*. For illustration, assume that piston, *D*, is one-half the area of *F*. (It can be more or less, as desired; the practice is to make it less.) Water is turned on the system, and passes freely through the valve until the pressure, accumulating in the pipes on the outlet side, is exerted on the full area of the valve beneath *M*. When 20 lbs. is reached an equilibrium exists, and any further rise of pressure at *B* will increase the pressure twice as much in chamber, *K*. This decreases the flow of water through *I*, and increases the quantity discharged through *O*, allowing the pistons, *F* and *T*, with valve, *M*, to slowly close until only enough water passes to maintain 20 lbs. pressure at outlet *B*. Should an

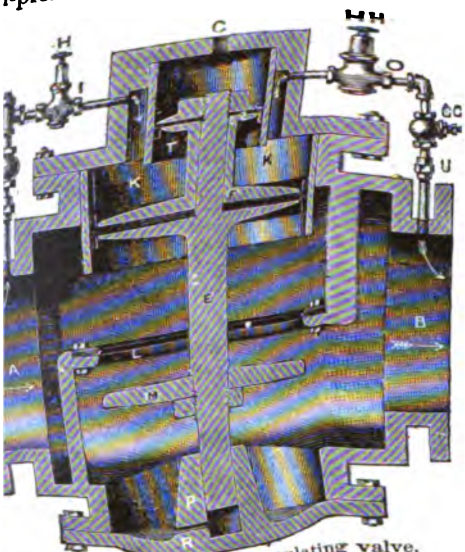


Fig. 5.—Ross pressure-regulating valve.

tra demand on the system cause the pressure to fall below 20 lbs. on the outlet side, *B*, relief valve, *O*, would close and regulating valve, *I*, would open, thus allowing pistons, *F* and *T*, with valve, *M*, to open, and allowing sufficient water to pass to keep the pressure at 20 lbs. Any rise or fall of pressure will continue to repeat this operation.

Fig. 6.—Union regulator. Detail.

ɢ. 7.—Union gas pressure regulator.

The Union Gas Pressure Regulator, made by the Union Water Meter Co., Worcester, Mass., is shown in Figs. 6, 7 and 8. It is built on the tank or gasometer principle. . 6 is a sectional view of the tank and piston connected the valve by rack and segment. Fig. 7 is a view of the with cap removed, showing the valve-stem and V-shaped . Fig. 8 shows the valve-stem detached from the valve with the four ports which open and close over four alternate parts in the valve-seat. The operation is as follows: The gas is taken from the low-pressure side of the valve by the pipe, shown in Fig. 7, to the under side of piston in the diaphragm case in Fig. 6. Then any increase of pressure immediately raises the piston and

ɢ. 8.—Union regulator. Detail.

oses the rotary valve by means of the rack, *A*, and segment, ; any decrease of pressure opens the valve. The rotary alve with V-shaped ports is operated by a piston with a olling diaphragm, thus giving a long stroke and graduating he flow of gas with the greatest accuracy. The conical form f valve admits of its being ground to a gas-tight joint, not ffected by contraction or expansion, and requiring no packing round the valve-stem. The ports have cutting edges and a hearing motion, thus effectually preventing the formation of e or the accumulation of foreign matter on the valve seats, hich so often prevents the closing of other forms of valves. y the rotary motion of the valve, and its opening and closg both ways from the center, a positive cut-off is effected

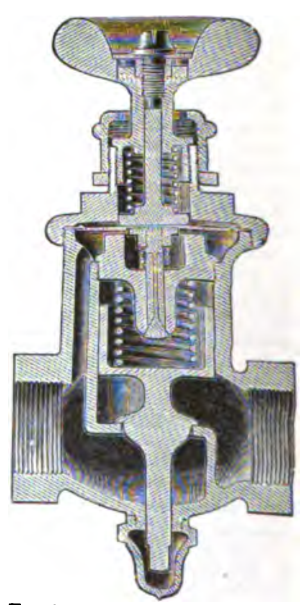


Fig. 9.—Curtis pressure regulator

The hammer always strikes on the rivet, heading it equally, and as it is rotated while ie blows are being struck, the head conforms to the shape of the peen of the hammer, id any style of head can be formed.

Riveting Machine, Hydraulic.—The riveting machine shown in Fig. 2 was designed and uilt by William Sellers & Co., of Philadelphia. It has a gap of 198 in. measured from the nter of the riveting dies to the base of the throat, and the distance between the frames stakes is 4 ft. 6 in. The ram is operated by hydraulic pressure, and is capable of erting variable pressures of 25, 50, or 75 tons upon the rivet, at the will of the operator, om a fixed accumulator pressure of 2,000 lbs. per sq. in. These variations are obtained rectly at the machine itself by a valve of special construction, and by the simple movement a single lever conveniently located. The stakes are of cast-steel, and the requisite spread obtained by means of the massive cast-iron box at the base, the whole being securely tied gether by the large through bolts shown. The cylinder is also of cast-steel, and has cast ith it the bearing for the riveting ram, which bearing is necessarily prolonged by the large erreach. The machine, instead of being placed in a pit, as is frequently the case, so as to ake the floor line form the working platform, is set with the bottom of the throat level with ie shop floor, and a platform (not shown) is attached to the main stake about 3 ft. below ie center of the ram, so as to bring the operators at the most convenient distance to the ies.

ROD-MAKING MACHINERY.—For making rods and dowels there is ordinarily employed a hollow arbor, having a head and cutters revolving about the rod, cutting it smooth and true. Rolls back of the cutter-head drive the material into the machine; these rolls having grooves made to fit the thinnest size of the rods, and being fastened to the shaft by set-screws, so that in working the rolls are moved sidewise to bring the right sized groove for the rod to be worked exactly in the center. In the latest machine the feeding arbor is vertical and center, the stock being turned.

Roller: see Seeders and Drills.

Roller Mills: see Ore-crushing Machines.

Rolling Machinery: see Leather-working Machinery.

Rolls: see Coal Breakers, Milling Machinery, Grain and Ore-crushing Machines.

ROLLS, BENDING. *Heavy Plate-bending Rolls.*—The full-page illustration, Fig. 1, represents the No. 12 power bending rolls made by the Niles Tool Works, Hamilton, O., for bending plates up to 2 in. in thickness. This machine is 22½ ft. between the housings, and has four wrought-iron forged rolls, 22¼ ft. long between the journals.

The two feeding rolls are placed vertically one over the other, and are 32 in. in diameter, and the two bending rolls are placed one on each side of the center rolls. These are 25¼ in. in diameter, and move in guides in the housings. They are so placed as to move very closely by the lower center roll when the latter is touching the upper roll. The upper feed roll runs in fixed bearings in the housing, and the lower roll runs in bearings having a vertical adjustment of 5 in., obtained by means of heavy steel adjusting screws 8 in. in diameter, operated by tangent gearing.

The bending rolls have an adjustment of 20 in. When in their lowest position the upper surface is 4 in. below the bottom of the upper feed roll, from which position they move upward until they touch the upper feed roll. The adjusting screws for these rolls are of steel, ' in. in diameter, and are operated by tangent gearing. The two bending rolls and the ower feed roll are raised and lowered by a pair of reversing engines, which are used for this urpose only. Clutches are provided in the train of elevating gear for all the movable rolls, that either one or both ends of any of them can be moved independently. Safety friction utches are provided in the gear train of the lower feed roll, which allow the gearing to p when the feed rolls and plate are pressed tightly together. Graduated index scales are ovided to indicate the exact height of the ends of the rolls.

The two feed rolls are positively geared together from opposite ends. The main gear on ch roll is 10 ft. diameter, 15 in. face, and 5 in. pitch. They are driven by a pair of reersing engines, whose cylinders are 12 in. diameter, and stroke 16 in. The machine is ounted on a heavy cast-iron sole plate, 18 in. deep, bedded in a massive stone foundation, nd sunk to a level of 7 ft. below the floor line. The plates are intended to pass through he rolls at a height of 19 in. above the floor. The reverse levers and throttles for the engines are operated from one common platform, erected on the sole plate, level with the floor, and all clutch and operating levers are brought to a convenient position above the floor.

Vertical Plate-bending Rolls.—Fig. 2 illustrates a vertical plate-bending machine, built by Thomas Shanks & Co., Johnstone, Scotland, which is capable of bending cold steel plates 1½ in. thick, and 12 ft. 6 in. wide. The front roller is of steel, 23 in. in diameter, and is adjustable to and from the inner rollers, which are 16 in. in diameter, of forged steel. The adjustment is by two screws driven by worm-wheels and vertical worm-shaft, with bevel gear worked from either side of the machine. The forged iron nuts of the screws form the slide and bearings which carry the journals of the front roller. The machine rests on four cast-iron stools, to which is bolted a strong frame carrying one end of the pinion shaft, containing two bearings for the back rollers, and a parallel space for the sliding block of the front roller. To this plate is also bolted a gearing frame, with the bearing for the cross-shaft and bevel pinion. These plates, with the four stools, are bolted to the masonry foundation. The top framing, carrying the rollers at the top, as also the top main pinion shaft, is cast-iron, and it is supported on a massive vertical standard, checked and bolted to the sole plates, and this forms a rigid frame to self-contain the strains. It is cast with bearings for the anti-

friction rollers. These are 12 in. broad, those at the sides being 10 in. in diameter, and at the back 18 in. in diameter. They are so arranged that they transfer the pressure off the roller to the vertical standard. The inner rollers are each driven by a large spur-wheel, 3½ in. pitch, worked by pinions, keyed to the connecting shaft, 8 in. in diameter, upon which also is keyed the large bevel wheel. Spur-wheels and pinions enable the gearing to be altered for heavy or light work. The engines for driving the machine are of the vertical type, having 12 in. cylinders.

Sellers' Bending Rolls.—Fig. 3 shows a set of vertical bending rolls, built by William Sellers & Co., of Philadelphia, which are capable of bending a steel plate 10 ft. wide, 1½ in. thick. The bending roll, 18 in. diameter, and the two side rolls, 15 in. diameter, are carried in heavy plate housings, and so united as to embody great strength, and at the same time leave the front of the machine unobstructed for the free curvature of the plate. All three rolls are driven by a pair of independent reversing engines. The bending roll is the principal driving roll, and the side rolls are adjustable to and from the bending roll by another

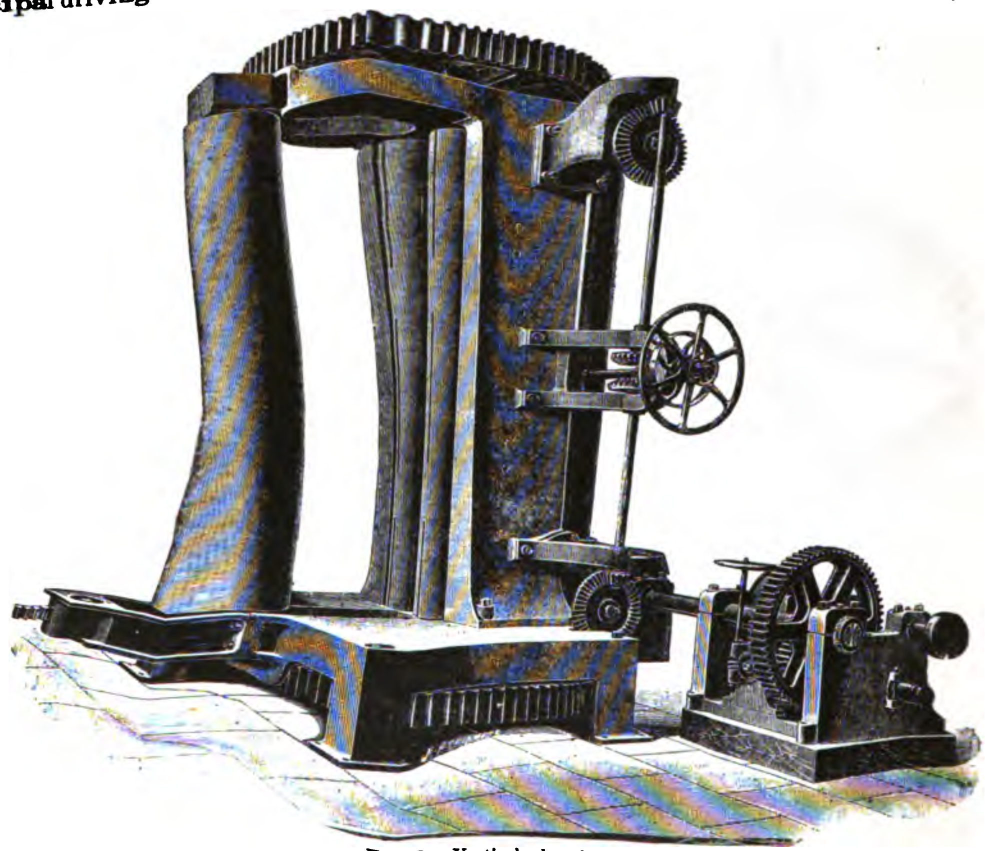


Fig. 2.—Vertical plate-bending rolls.

pair of independent engines, controlled by convenient levers, and so arranged that the two ends of the rolls may be adjusted together or independently in either direction. The driving wheels at the bottom of the side rolls are of steel, while the bending roll carries at its upper end a spur-gear wheel over 5 ft. in diameter, and about 4 in. pitch by 11 in. face, driven by a steel pinion. The bending roll, with its upper bearing and driving wheel, can be withdrawn by an overhead crane for the removal of flues. Hitherto the problem of driving all the rolls at the same peripheral speed has been embarrassed by the calendering action developed in the passage of a curved plate. To avoid this action, and at the same time relieve the driving gear of unnecessary strain, there is provided in the train of gearing for the side rolls a positive clutch with sufficient lost motion to allow for the maximum effect of calendering. The work of driving the plate through the rolls is thus thrown chiefly on the gearing, which drives the middle roll, and although the pinions on the side roll are thus relieved of the work of driving, they are always in readiness to assist, should the friction of the middle roll on the plate be insufficient to carry it through.

The Niles Plate-straightening Machine, shown in Fig. 4, is designed for straightening plate iron for boilers, tanks, safes, etc. It has seven rolls arranged in two tiers—four rolls

ROLLS, METAL WORKING. *Roughing Train and Doubling Machine for a Tin-plate Rolling Mill.* — Theodore L. Thomas, of the Union Works of the Illinois Steel Co., Chicago, has designed a mill for rolling tin-plate bars, which is herewith illustrated, Fig. 1 showing the side elevation, and Fig. 2 the ground plan. Mr. Thomas has also devised a doubling machine, likewise shown in the illustrations, which is an important part of the apparatus. This mill is intended to break down tin-plate bars and prepare them for the usual finishing train. It consists of three sets of rolls, three high, inclosed in one pair of housings and driven by one engine, as indicated by the gearing. The doubling machine consists of four folding-doors lying at floor level, with shears in the center.

In the usual method of making sheets for the tinning process, the practice followed is to

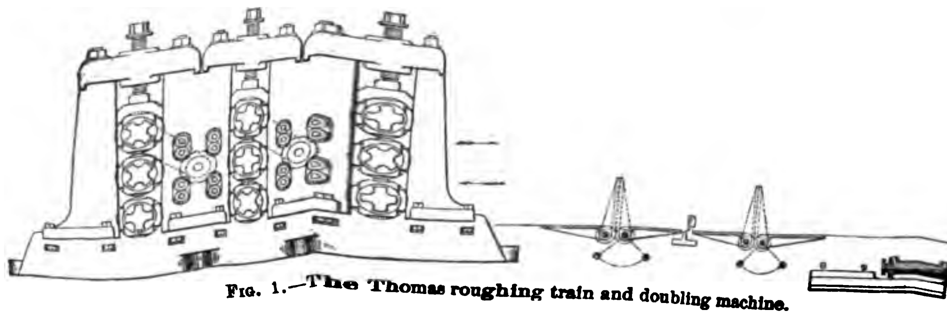


Fig. 1.—The Thomas roughing train and doubling machine.

take a 7-in. bar, cut to suitable width, which is subjected to five heatings and five rollings, with four doublings. The five rollings are known to millmen as (1) molding, (2) singling, (3) doubling, (4) fours, (5) eights, finishing to suitable lengths. The description applies to what is known in the market as IC 20 x 14. By Mr. Thomas's method a 14-in. bar is taken. It is heated, passed through the lower rolls in the direction of the arrow, shown in Fig. 1, and then back through the upper rolls. The rolls are adjusted by lining, graduating the work on the bar throughout the six passes. Guide rollers between the rolls keep the bar in proper position for the next rolls. The rolls are a sufficient distance apart to prevent buckling. The sheet which emerges from the last pass is trailed on the floor a little on one side of the doubling machine. It is then pushed by machinery on the folding-doors and into the shears, which cut it in two. The doors next move into a perpendicular

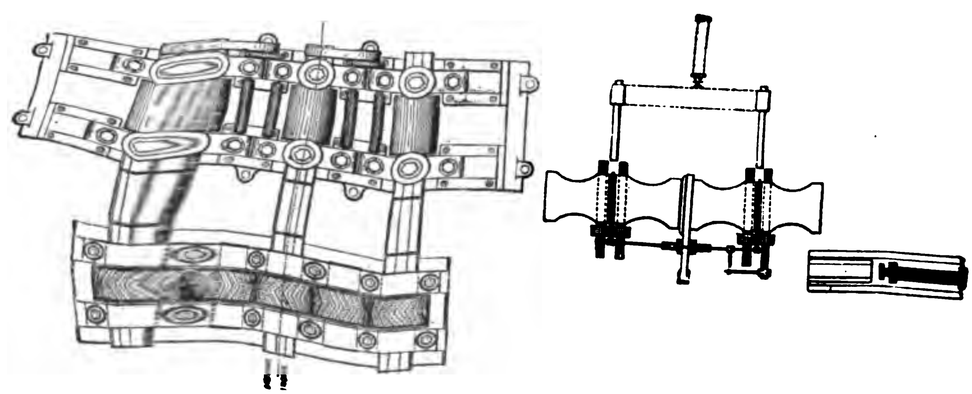


Fig. 2.—The Thomas roughing train and doubling machine.

position, thus doubling the two sheets at one operation and one heat. The doubling machine is operated by hydraulic or steam cylinders.

Two-fifths of the work of rolling the black sheets is performed at this stage, leaving three-fifths to be done in the finishing mill, to which the doubled sheets are taken by an endless chain or other labor-saving device. The finishing mill being thus relieved of two-fifths of the work of rolling the black sheets, can be operated with much greater capacity than by the old method.

The Simonds Metal Rolling Machine.—A novel machine for the rolling of special shapes of metals, built by the Simonds Rolling Machine Co., of Fitchburg, Mass., is shown in Fig. 3. The machine is designed for rolling accurately and in a short space of time a large variety of work which at present is turned out by more laborious and expensive processes, such as lathe turning, the customary methods of forging, and others. The machine

these for this purpose being as shown in Fig. 4. The die there illustrated is for forging
axles, of one of which a sketch is also given. The dies are used in pairs, moved in opposite
ections over the metal to be shaped, the die surfaces, of course, being exactly alike.
m the plane faces of the dies, which lie parallel to each other when in position for
k, rise the forming and reducing and spreading surfaces, the plane portions serving
support and steady the work and prevent it from rocking. The reducing surfaces are
oved or serrated, in order to insure a firm grip on the hot and plastic metal, and perfect
ularity in its rotation, and being thus arranged obliquely, the marks made in the metal
the serrations are obliterated in subsequent revolutions of the blank, and the rate of the
face movement of the latter, where work is being performed, is the same as the rate of
ar movement of the dies. The reducing faces commence to work on the metal at the
reme left, where they meet in a point, and when the hot blank is placed between the dies,
central reduction of the axle is commenced by the narrow end of the tapering raised
tion, a, of the die face. In general configuration, the raised portions are like the half
ion of the axle, the shearing off squarely of the ends of the axle being accomplished by
level edge cutters, cc. The edges of these cutter projections are also serrated, so that the
ation of the blank is under control throughout the length of travel of the die. The
terial operated upon is compressed and condensed as it assumes the required shape
der the dies. The construction and function of all other forms of dies for use in the
chine are on the same general basis.
The blank to be operated upon is inserted between the dies, and rests on the supporting
te marked V, in Fig. 3, one of the dies being at or near the end of its up stroke, and
other at or near the end of its down stroke, so that the extreme ends of the gripping
rfaces of the dies are opposite each other in a line passing through the centers of the
afts, A A. One of the die platens travels up and the other down, until the extrem-
es of the cutting-off edges are opposite each other, when a finished car-axle, or whatever
her product the dies may have been designed for, is the result. The whole operation
cupies only a fraction of a minute. The smaller the article made, the greater may, of
urse, be the speed of working; boot calks for lumbermen, for example, being turned out
the works of the Simonds Rolling Machine Co. at the rate of from 10,000 to 20,000
er day.

The Munton Process of manufacturing Steel Tires.—The Chicago Tire and Spring
o., of Melrose, near Chicago, Ill., use a plant for the manufacture of locomotive and
ar-wheel tires and circular forgings which, in its method of treating steel, is a marked
eparture. Mr. James Munton, the superintendent, is the inventor of the new process and
he machinery for operating it. The ordinary method of manufacturing tires is to cast a
olid ingot of cylindrical shape, which is then heated and upset under a steam-hammer until
ts height is reduced and its diameter enlarged. After a hole has been punched in its center,
the ingot is then placed on a beak or pike-horn and hammered by blows struck on the periphery. It is then again heated and placed in a rolling mill, and rolled into a tire of the required diameter. In Mr. Munton's process he avoids the use of the hammer altogether, and in elongating the ingot, or bloom, into a tire he densifies the metal on the tread and increases the wear-resisting properties of the steel.

FIG. 5.—Ingot as cast.

A brief summary of the several steps taken is as follows:
(1) The ingot is cast with a hole cored out large enough to admit a small roll. (2) The ingot is heated and taken to
rolling mill, where its top, with its imperfections, is sheared off and the bloom left of
ven weight. At the same heat, and by the same operation, the bloom is also roughed out
he roughing rolls of the mill and edged
n by horizontal rolls. (3) The bloom is
eated and placed in the tire rolling mill,
ere it is rolled and finished to the exact
side and outside diameter required. Mr.
unton's present practice is to cast an ingot
rge enough for two or more tire blooms.
le uses a collapsible steel core. The steel is
roduced in an open-hearth furnace and poured
from a ladle into the molds over a spreader
of circular form, which covers the core and
causes the steel to flow down on all sides,
keeping any dirt in it flowing and thus col-
lecting at the top. Fig. 5 shows a cross-
section of an ingot as first cast, before slit-

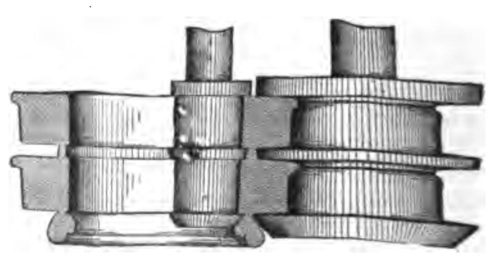


FIG. 6.—Ingot and slitting rolls.

ting. Fig. 6 shows a two-tire ingot partially slit, and also indicates the method by which
the slitting is done. In slitting, two upright rolls are used. One roll operates upon the
inside of the ingot, as shown above, while the other roll operates on the outside. The
outside roll is driven. It has a sharply beveled edge as a top cutter, a projecting flange
as a central cutter, and a bottom flange to support the base of the ingot. Grooves are
formed in this roll at suitable places to partly shape the tread of the tires. The flanges all
extend the same distance outward from the roll. The inside roll has projecting flanges to

o a pair of rolls. He then obtained a patent on the process, but no commercial results owed. Experiments have recently been made in the United States on the same process, h such a degree of success that it has already been introduced as a commercial process. 1891, forty-five years after his original experiments with glass, Sir Henry Bessemer read aper before the Iron and Steel Institute of Great Britain, describing his proposed methods remedying the defects of his first apparatus. From this paper (see *Engineering*, October 9, 1), we abstract the following:

The rolls, *L* and *M*, Fig. 9, consist of two hollow drums through which a tubular steel axis, *V*, passes, and conveys a plentiful supply of water for keeping the rolls cool. The brasses ch support the roll, *M*, are fixed, while those which support the roll, *L*, are movable in a able slide, and are pressed on by a small hydraulic ram, which is in free and uninterrupted imunication with an accumulator, so that at any time should the feed of metal be in excess, roll, *L*, will move back and prevent any undue strain he machinery, the only result being a slightly increased ckness at that part of the sheet of metal, a defect ich, as it extends parallel across the whole width of sheet, will be easily corrected in the next rolling eration. The rolls by preference may be made 8 ft. or t. in diameter, each having a flange on one end only, d thus form a trough with closed ends for containing e fluid metal. In order to obtain a regular and quiet pply of metal, I employ a small iron box or reservoir,

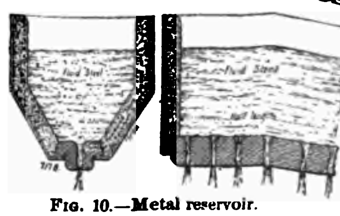


Fig. 10.—Metal reservoir.

g. 10, lined with plumbago or fire-clay; along the bottom of this reservoir some 10 or 20 small holes of about ¼ in. in diameter are neatly olded by a row of conical brass pegs. The reservoir is provided with a long bar or handle each end. By means of these bars the reservoir is supported on the side frames, the bars lling into suitable notches made in the roll frame for that purpose. A pair of rails, *Q*, are ipported on the roll frames, and serve for the conveyance of the ladle, *R*, which is mounted n wheels, and brings the metal direct to the rolls, or to any number of pairs of rolls that ay be placed in line. The ladle is provided with one or more valves or stoppers of the usual ind, by means of which the supply of metal to the reservoir, *P*, may be easily regulated; the everal small streams from the reservoir will deliver an almost constant quantity of metal, arying only slightly as the operator regulates the head of metal in the reservoir. From the mallness of the head of metal in the reservoir the several streams will fall quietly without plashing. These streams do not fall direct onto the rolls, but into a small pool formed etween the thin films solidifying against the cold surface of the rolls, the metal at all times eing free from floating slags. The speed of the rolls also affords a means of regulating the uantity of metal retained between them; and as a pair of 4-ft. rolls would only require to nake about four revolutions per minute, a quick-running engine could easily be provided vith differential speed gearing, so as instantly to alter the speed of the rolls to the very small xtent ever required during the rolling process.

The thin sheet of metal, as it emerges from the under side of the rolls, is received etween the curved guide plates, *S* and *T*, to the latter of which a cutting blade, *U*, bolted. Beneath the guide plate, *S*, a similar cutting blade is arranged to sudnly move forward by a cam and cut the thin sheet in two, the piece so cut afterward ssing between the second pair of rolls, *V V*, from which it again descends by gravity, l passes between the third pair of rolls, *W W*, and is delivered onto a horizontal le; or it may be allowed to slide down the inclined end of a cistern of water, and moved wly forward. By these means it will be possible to cool and stack a ton of plates without labor or trouble. The thickness of plates capable of being produced will much depend the size of the rolls; if drums of 10 ft. or 12 ft. in diameter are employed, it is probable t plates of 3 in. in thickness could be produced, or, perhaps, even thicker. The central ce between drums of such large diameter would represent a sort of plate ingot mold with rly parallel sides for some 8 in. or 10 in. in depth. With reference to speed of producn, let us assume the mill to be fitted with a pair of 4-ft. diameter rolls, 18 in. wide, and aking four revolutions per minute, and set to produce a sheet having an initial thickness of in., and rolled by the third pair to $\frac{1}{20}$ in.; we should thus have a surface velocity of the rst pair of rolls equal to 50 ft. per minute, and making, when finished, 100 plates 18 in. by 2 in., $\frac{1}{20}$ in. thick, and weighing 300 pounds, or equal to a production of one ton of plates n seven and a half minutes. Hence it becomes a question which is the least costly mode of dealing with a ladleful of fluid steel, forming it into massive ingots in molds, or making it into thin sheets in the manner proposed.

It appears from Sir Henry Bessemer's paper, above quoted, that he did nothing to develop the process after his experiments in 1856 for over thirty years, nor until he had learned that success had been reached in America in the same direction. Meanwhile, Mr. Edwin Norton, vice-president of Norton Brothers, Incorporated, of Chicago, manufacturers of tin-plate and tinware (see the presidential address of Robert W. Hunt, before the American Society of Mechanical Engineers in November, 1891), had been experimenting for some years on the process, and in conjunction with Mr. J. G. Hodgson, had obtained various American and foreign patents. (Apparatus for making sheet metal, Nos. 382,319 and 382,321, May 8, 1888; No. 406,945, July 16, 1889. Apparatus for manufacturing railroad rails, No. 406,944, same date. Manufacture of metal bars or rails, No. 406,946, same date.) As sheet rolling mills under these patents are now working commercially at Whitestone, Long Island,

meeting faces or peripheries of the rolls, *B*, are given a shape or configuration to form an ordinary railroad rail. They may, however, be shaped to give the space or passage, *b*, any desired cross-section, and thus produce a bar of any form required. The rolls, *B*, have beveled faces, *b'*, which meet or roll against each other, and serve as stops for the several rolls against each other, so that the space or passage, *b*, for the metal will always be maintained of a uniform size, and thus produce the rail or bar of a uniform cross-section throughout. The rolls, *B*, are each made hollow, and preferably with a central web, *B'*, and the shafts, *B*², are also made hollow, so that the water or other cooling fluid or liquid may be made to circulate through each of the rolls for the purpose of keeping them cool or of the desired temperature. The hollow shafts, *B*², are each furnished with a packing or stuffing-box, *d*, at each end, by which they are connected with the inlet and outlet water pipes, *D D'*. The pouring bowl or vessel, *C*, is supported by any suitable means above the rolls, *B*, during the pouring operation, preferably by standards, *C'*, furnished with adjusting screws, *C*². The pouring nozzle, *C*, is preferably furnished with a valve or device, *c*, for opening and closing the discharge passage. The hollow shafts, *B*², of the rolls are all geared together, so that they revolve or roll together at the same surface speed. The gearing employed may preferably be bevel gears, such as indicated at *B*³. Two of the shafts, *B*², are also geared together by spur gears, *B*⁴. *E* is the driving shaft, having a gear, *E'*, which meshes with a gear, *E*², on one of the shafts, *B*². The pouring bowl or nozzle, *C*, is furnished with a guide or shield, *C*³, extending down to near the meeting point of the rolls. This is designed to prevent the metal from splattering at the beginning of the pouring operation. A greater or less number of rolls than four may be employed. *F* represents a second series of rolls, arranged preferably directly below the chilling rolls, *B*, and between which the bar, *x*, passes as it issues from the chilling rolls, *B*. The series of rolls, *F*, are preferably of the same form and construction as the rolls, *B*, being hollow and having the same connections for passing water through them, so that they may operate as chilling rolls as well as to further roll, compress, and finish the rail or bar produced. The rolls, *F*, may, however, be of any ordinary or known construction. The series of rolls, *F*, is preferably like the series, *B*, composed of four rolls revolving together. *G* is a curved guide or conveyer, consisting preferably of a series of rolls or idle pulley wheels, arranged in a curved path to curve and guide the bar as it issues from the rolls, *F*, to the horizontal conveyer or series of rolls, *H*. Some of the rolls, *H*, are preferably driven and operated to further roll and straighten the rail or bar, as well as to convey it along or away. The curved guide, *G*, also affords some slack in the rail or bar between the chilling rolls and rolls, *H H*, to compensate for difference in speed or slipping.

Rope Driving: see Belts and Cranes.

ROPE-MAKING MACHINERY. Hemp Rope.—*Preparation machinery* may be divided into two classes: the drawing or single-chain machine, and the heckling or double-chain

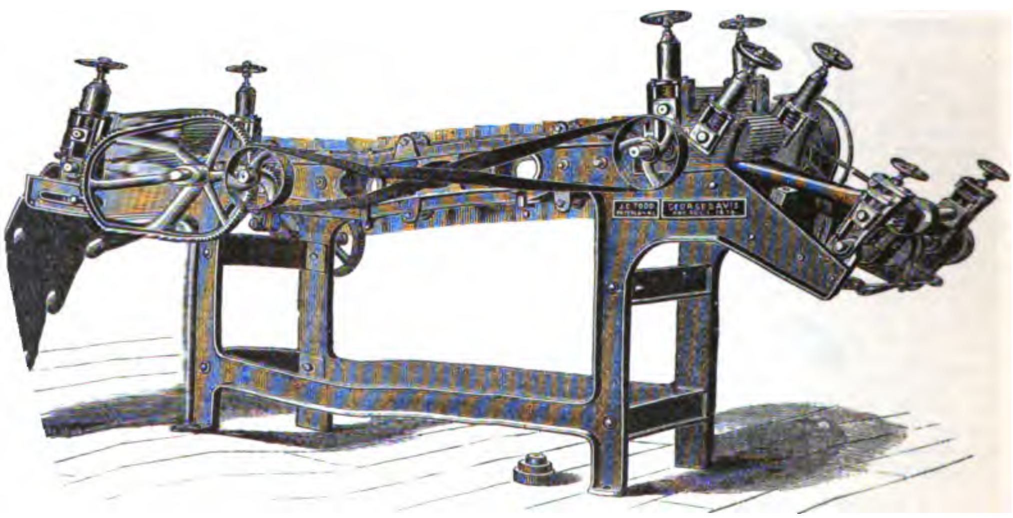


Fig. 1.—Hemp-drawing machine.

A chain is an endless combination of bars linked together, the distance between each being equal. The bars are of iron, round or square, varying in size from ½ in. to 1¼ are studded with pins which vary in length, thickness, and distance in about the tive proportions as the bars. The heavier the bar, the coarser the pin, and being largest at the beginning of the preparation, and decreasing in size on each suc- working machine. At each end of a bar is a "dog," which is moved through guide ed on the sides of the machine, in such a way as to keep the pins in a vertical

and combing process. In the case of Manila, owing to the fineness and softness of the hemp at the top or seed end, the fibers are not separated, but are bunched together into a towy mass. In order to separate the fiber and remove the tow, an operation termed scutching is introduced. A bunch of hemp is seized at the middle of its length, and the seed or top end thrown against the rim of a swiftly revolving cylinder. The rim of this cylinder is thickly studded with steel pins or blades about 4 in. long. Being held so that the seed end comes in contact with the rapidly-moving pins, the hemp is teased out, the fibers are straightened, and the tow removed from the hemp, and thrown from the cylinders by centrifugal force. The hemp is sent to the breaker, Fig. 2, a machine of the second class, on the slow chain of which it is fed, and firmly held by the pins which pass through it. In front of the slow chain is the fast chain, the relative speeds being about as 10 to 1. The hemp being firmly embedded on the slow chain, and the pins of the fast chain passing through each portion of the hemp as presented, the fiber is straightened out, and in each revolution of the fast chain a body of hemp is drawn into a sliver of ten times the original length. Naturally, this sliver is not even or uniform throughout its length, due in most cases to irregular feeding, unequal softening of the hemp, and to riding over the pins on the fast chain. To correct the inequalities, 6 or 8 slivers are fed on the slow chain of a second breaker, which operation further completes the separation and straightening of the fiber, and at the same time makes the sliver more uniform throughout its length.

The subsequent operations are essentially the same as described above; 6, 8, or 10 slivers are placed behind spreaders, Fig. 2, consisting of a slow and a fast chain. The bars in these chains are in each successive working brought closer together, and also the pins are finer, and the distance between each two bars or pins made smaller in each case. Sisal receives from 5 to 8, and Manila from 4 to 6 workings on the double-chain machines. The sliver is then considered sufficiently even and the fibers soft and elastic. A number of such slivers are placed back of a drawing frame or single-chain machine, Fig. 1, to be drawn to a size which will admit of its being spun into yarn or thread of from 300 to 600 ft. to 1 lb. The drawing frame, Fig. 1, is made up of a chain studded with fine pins, and in place of a fast chain is a pair of fluted iron rollers, with a speed of four or five times that of the chain. This difference in speed will reduce the slivers to one-fourth or one-fifth the original size by drawing them to a single sliver four or five times the original length. After one or two workings on the drawing frames, the sliver is ready for the spinning or jenny room, where it is spun or twisted into yarn of any desired size.

The diagram, Fig. 8, shows the usual arrangement of the various machines making up a "set." The capacity of this set is from 12,000 to 15,000 lbs. per day.

The main defects of this system are the tendency of the fiber to ride over the pins of the fast chain (which is natural, on account of the speed of this chain), and in the space between the last pin in the detaining chain and the first on the fast, or combing chain, which is of necessity so great as to let a portion of the stock go from one to the other without being cleaned, combed, and straightened. These defects cause an amount of raw or unworked hemp to show in the sliver, and render the number of successive operations necessary to repair this fault.

The machinery, as described and illustrated above, is the type in general use throughout the United States.

Fig. 4 shows the style of chain used in foreign preparation machinery. The great difference between these machines and those previously described is in the mode of drawing the bars or gills. As we have seen, in the former machines the bars are driven by a carrier-wheel, but the bars in this machine are driven by a horizontal screw, which forces the pins in and out of the fiber at right angles. The front chain in this machine consists of two sets of bars, one above the other, shown by Fig. 4, producing an absolute certainty of action, as the pins in the bars intersect and prevent any possibility of the fibers riding over the points of the pins. And on account of the intersecting bars there are twice the number of pins in action at the same time as would be in the case of the machine shown in Fig. 3. The action of this machine is, therefore, much better than that of the former set. There still remains the fault due to the distance between the chains.

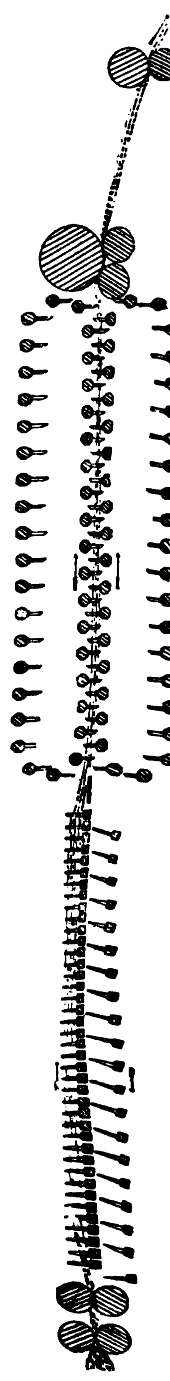


Fig. 4.—Combe, Barbour & Combe's chain.

The latest form of preparation machine invented by A. W. Montgomery, New York, is

revolution of the flier puts one turn into the hemp drawn through, forming it into a thread; and at the same time winds an equal amount of spun yarn on the bobbin, which holds about 15 lbs. The bobbins are sent to the rope-walk or rope-machine room to be made into rope. Rope of a diameter of ¾ in. or less is made on rope machines, Figs. 8 and 9. That of larger diameter is made in the rope-walk, although rope machines have been built to make the larger sizes. Fig. 8 represents the "former," on which the yarns are twisted into strands, and Fig. 9 the layer, on which these strands are "laid up" into rope. The size of a rope determines the number of threads necessary to make it. One-third this number are twisted together into a strand when a hawser-laid rope is wanted, and one-fourth when a shroud-laid rope is required. Either the three or four strands, as the case may be, are in turn twisted together to form a rope. The two operations are performed at the same time on some rope machines, but separately on others and in the rope-walk. A description of the rope-walk process will suffice for both. In the rope-walk the bobbins are mounted upon a rack; the requisite number of threads to make a strand are passed through the same number of holes in a perforated plate to and through a trumpet-shaped tube, and fastened to a hook on the forming machine. This hook can be geared to revolve a definite number of times per each foot of travel of the "former;" in this way a regular amount of turn is put into the strand. The turn varies with the size of the strand, more turn being required in the small than in the large sizes. The length of the track limits the travel of the "former" and the length of the strand. Six strands are usually made at one time. As many strands as are required for the rope are stretched at full length along the walk, and attached at each end to hooks on the laying machines—the foreboard, being at one end, is stationary, and the

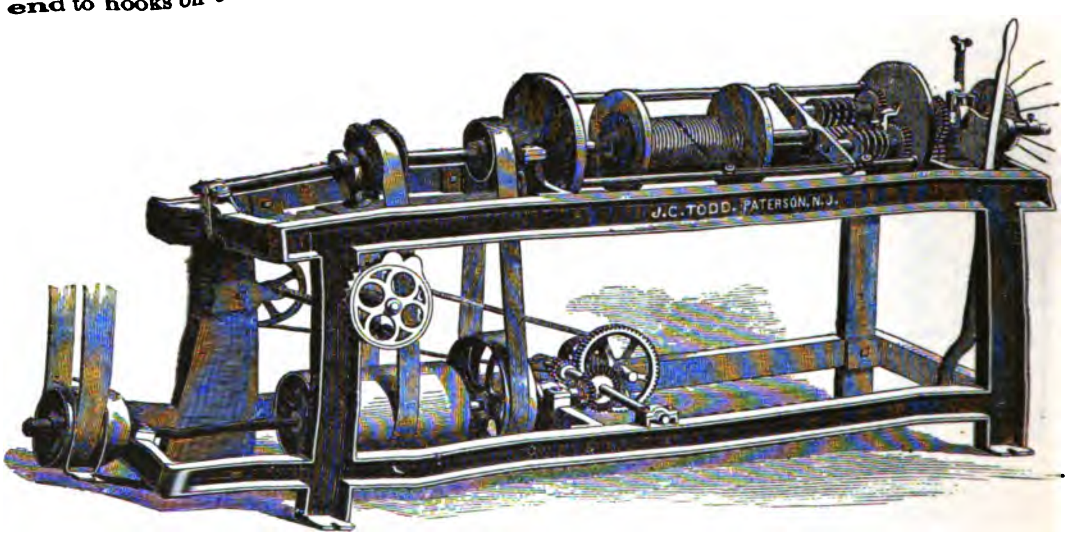
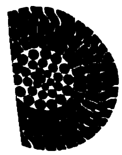


FIG. 8.—Strand-forming machine.

traveller at the other moves up and down the walk. The hooks of both machines are set revolving, continuing the "foreturn" placed in the strand during the forming process. Why this step is necessary has been explained. At one of the "laying" machines, each strand is in turn removed from its hook and laid in one of three equidistant concentric grooves of a cone-shaped block called a "top," and then fastened together on the center hook of the machine. The hooks of the two machines are now set revolving, the direction of turn at one end being the opposite of that at the other end. As a consequence, being fastened at one end to one hook, and at the other end to three hooks, the strands turn or twist on themselves at the end where there is one hook. As the twist is communicated to the strands between the single hook and the "top," the latter is pushed forward, leaving the laid rope behind it. Care must be exercised in guiding the block, for on its uniform motion depends the firmness of the rope, as well as the regular and uniform character of its "lay."

Trautwine says: "The tarring of ropes is said to lessen their strength, and when exposed to the weather, their durability also. We believe that the use of it in standing rigging is partly to diminish contraction and expansion by alternate wet and dry weather." Haswell speaks of tarred ropes being 25 per cent. weaker than white or untarred ropes. Russian hemp rope agrees with the conclusion laid down by both writers; but the Manila and Sisal hemp ropes were not affected at all in strength, although 20 per cent. of tar was added. The loss in strength was due to the tarring process. The ropes were formerly passed through a tar bath of a temperature of from 210° to 240° F. This temperature, being sufficient to singe off the hairs or stray fiber usually appearing on the surface of a rope,

sts in the employment of various suitably shaped wires, which, when closed together, ock and present a structure with a uniform wearing surface, in which each component is permanently held in its proper normal position. The transverse section, Fig. 12, shows a rope composed of an ordinary wire core, around which a series of cylindrical and radial wires are closed, followed by an outside shell of sectional wires, which are locked or held down in position. The various succeeding layers of wires are laid in alternate directions—*i.e.*, one to the right hand and the next to the left, and so on, as in the manufacture of some compound strands previously referred to.



2.—Wire rope section.

The modern type of wire-stranding and rope-closing machinery is shown in Figs. 13 and 14. The selected wires of requisite gauge are contained or coiled upon the bobbins shown, or mounted in the "flyers," carried by the circular frame, which is fixed to a horizontal shaft mounted in bearings, so as to be free to revolve through the intervention of appro- gearing. The outer ends of the wires are passed through apertures provided in the ar framing and nozzle plate running in the headstock bearing, and thence are carried gh the fixed closing block or die—shown closed by means of the weighted lever—to the

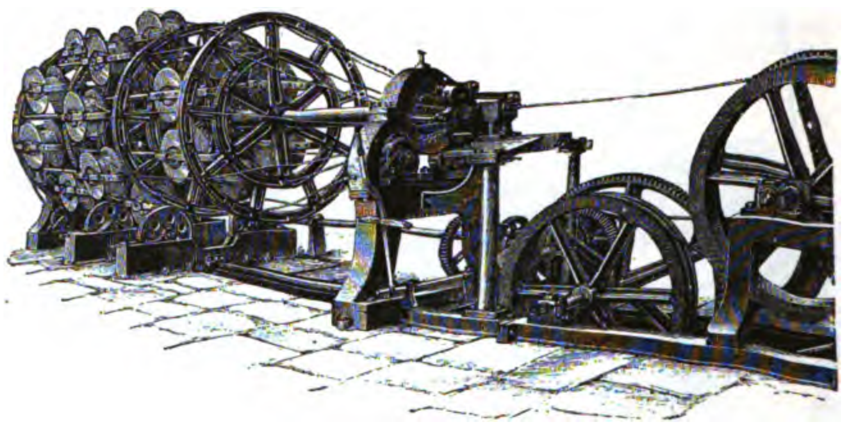


FIG. 13.—Wire-stranding machine.

off drums. The hempen or wire core is drawn in centrally from the back of the machine gh the tubular horizontal shaft, and as the machine revolves and draws in the core, the are twisted spirally round the same. The tandem grouping or arrangement of the bob-

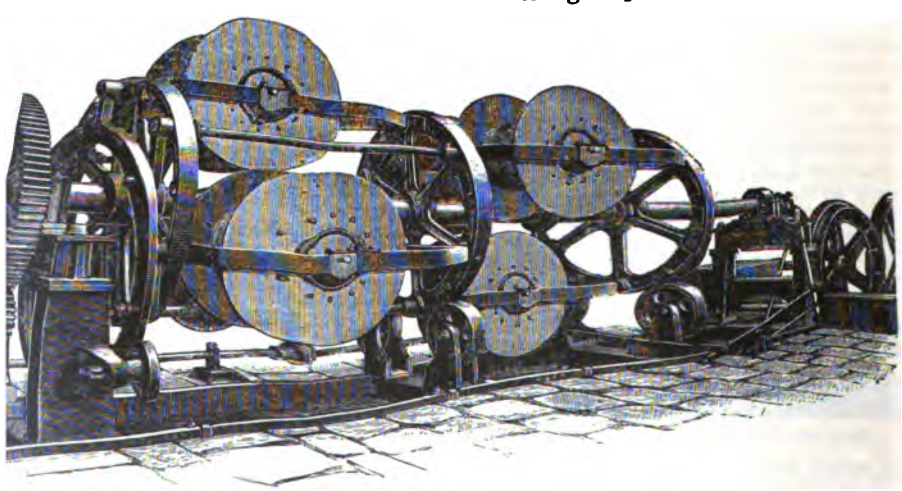


FIG. 14.—Wire-rope closing machine.

orthy of notice, and consequent easy angle at which the wires are concentrated at the ite, and drawn through the closing die. In this manner the strands are twisted up ending or straining the component wires, whilst any undue slack arising from any

SAFES AND VAULTS. I. BURGLAR-PROOF CONSTRUCTION.—The highest skill of the safe-maker is now devoted to the construction of strong-rooms and vaults for banks and safe-deposit companies.

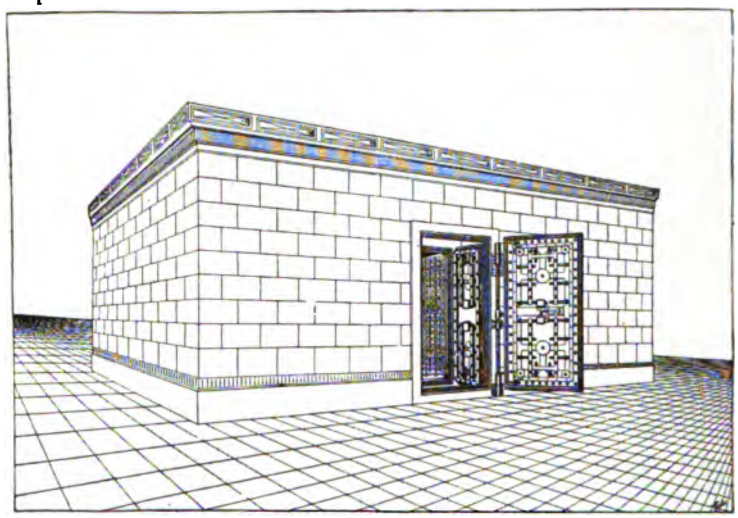


FIG. 1.—Safe-deposit and bank vault. Elevation.

Safe-deposit and Bank Vaults.—Fig. 1 represents a front elevation of a structure intended to be proof against not only fire and burglars, but the depredations of a riotous mob.

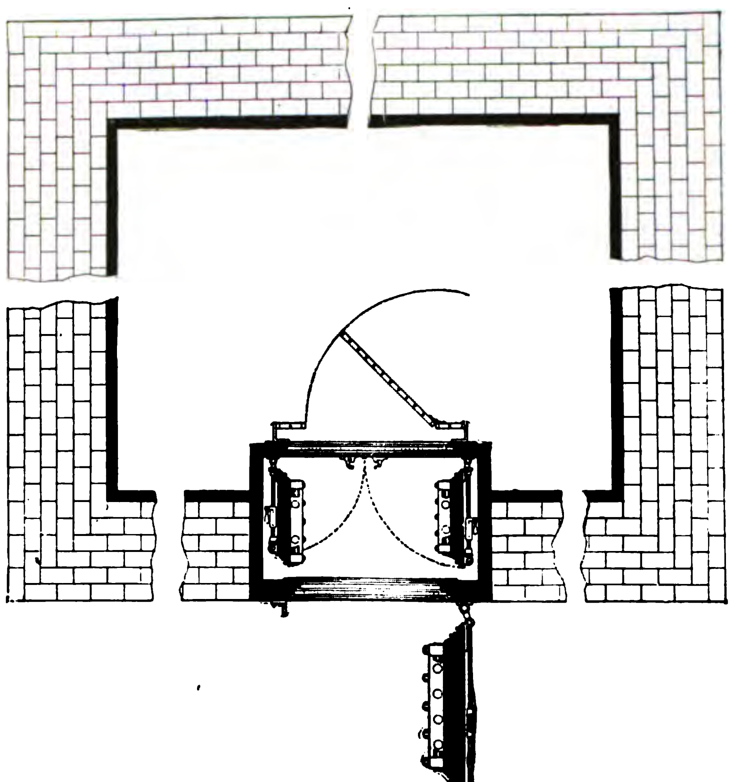


FIG. 2.—Safe-deposit and bank vault. Plan.

A steel vault is provided with an outside wall of stone or brick, 2 ft. in thickness and laid up in cement; the vault rests upon a foundation especially prepared for it, and is usually

s to form angles. The third layer is placed at right angles to the second layer, and d thereto with the ¾-in. welded steel and iron bolts, which pass through the third and are tapped into the full thickness of the second layer. The fourth layer parallels ›cond layer, and is bolted to the layer by the ¾-in. welded steel and bolts passing through the fourth The fifth or final layer is of Bes- steel plates, ½ in. in thickness, se- to the fourth layer by similar bolts ›se used in the preceding layers. ›tal thickness is 3 in., but the thick- varied by the addition to, or reduced ‹ing from. the number of plates or in the vault, according to the de- ›f security desired. The vestibule ıstructed of the same material and › same manner as the body of the except that in most cases its thick- s increased ½ in. over that of the itself The vestibule is usually tel- ›d into the vault, as shown, and is l to the walls of the vault with re- l angles, as shown. The outer or door is usually made 5 in. thick, of ate layers of the five-ply welded ıe steel and iron, as shown, secured ıer with the ¾-in. welded steel and ›olts, placed at average distances of from centers, and great care being ed, as in bolting the layers of the that no two bolts align each other. ›lt frame is of steel, forged into a ıous frame, and secured to the ›dge of the door by conical bolts, ›f the best wrought iron, with the conical parts of hardened welded chrome steel ›n. These bolts start with and extend through the sixth, seventh, and eighth layers ıd through the bolt frame. The inner doors are made folding, as shown in Fig. 2, › right-hand door overlaps and interlocks with the left-hand. These doors are usually made 3½ to 4 in. in thickness of materials, and put together in the same manner as already described for the outer door. Through the bolt frame of the outer door extend not less than twenty-four round revolving steel bolts, each 2 in. in diameter. They are checked by the time-lock and by two four-wheel combination locks, so arranged as to require that both locks must be unlocked before the bolts can be retracted. They are further arranged so that, if desired, one of the locks will release the bolt-work. Each inner door is fitted with not less than sixteen round revolving bolts, 1¾ in. in diameter, also checked by two four-wheel combination locks, so arranged that one lock, at least, on each door must be unlocked before the bolt-work of either door can be retracted. The lock and bolt-work spindles are of steel, in conical sections, closely ground to fit, and packed so as to be absolutely proof against the introduction of explosives. They can be neither driven in or drawn out, and by reason of their peculiar construction do not develop the structural weakness which appears in former methods of spindle construction. In addition to the locks on both the outer and inner doors, each ›uipped with a gravity device, to operate the instant the locks are forced from ›urface of the doors, so that the doors will remain locked or fastened, even though hemselves should by any means be driven from their fastenings. All the doors

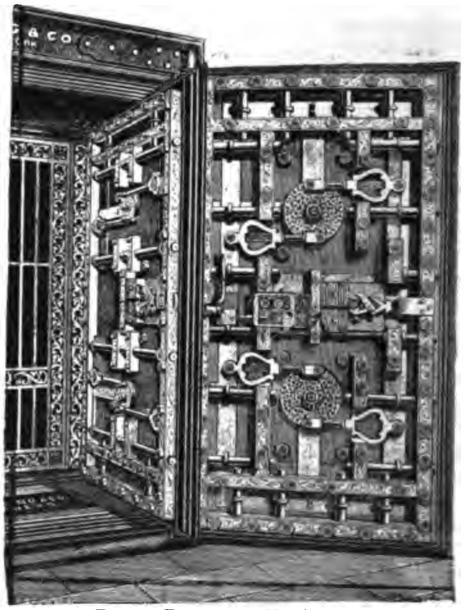
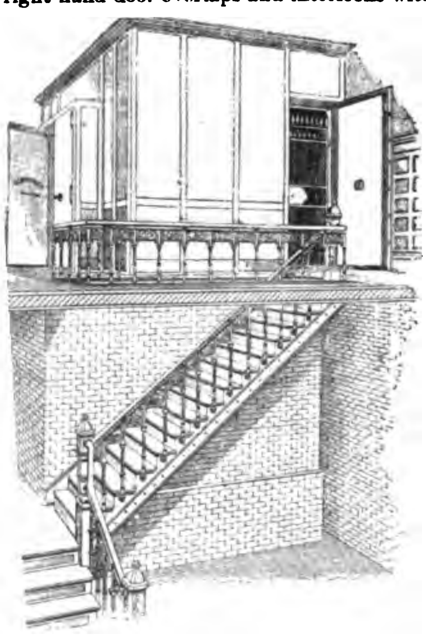


FIG. 4.—Entrance to Herring vault.



›. 5.—Vault, Chemical Bank, New York.

each jamb, so that when closed the doors are firmly keyed to the body of the structure. There are 20 steel bolts in each door, which secure it on all sides. These doors are made fast by two Dexter bank locks, which may be unlocked by either of two dials. They are safe against a lockout, or they may be arranged to require the presence of two persons, each one controlling a dial with a distinct combination. Besides this, each one of the outer strong doors has a time lock attached. This, however, is not the only protection against burglars. Inside the vaults are 12 Herring's safes, in which the many securities and different funds of the bank are kept separate, fixing individual responsibility to the last degree. Referring again to the upper vault, the fire-proof casing extends back of it to the wall, providing a space in which the books of the bank are stored for safety against fire. Referring to the cut, the door shown at the right in the upper vault leads to the book receptacle just described. It would seem that the precautions taken against loss by robbery or by fire in this bank are as great as may be. In the first place, there is the fire-proof building already described; next the fire-proof casing of the vault, inside of which is the vault proper, and then, in turn, inside of this are safes of the most thorough construction. In view of the fact that the bank has resources amounting to some \$80,000,000, the need of these precautions will be appreciated.

Fig. 9.—Herring safe.

Type of vault, constructed of plate steel and railroad rails, is represented in Fig. 7.

Burglar-proof safes are constructed in the same manner and in the same materials as vaults, being in fact little more than miniature reproductions of the latter. Fig. 8 represents a new form of Marvin safe, made of steel and provided with an inner chest. Fig. 9 is a solid-door bankers' safe, made by Messrs. Herring & Co., which has the novel feature of a solid outer door, with a smooth steel surface, unpenetrated by spindle or arbor. When the time-lock has unlocked at the time set, the bolts may be operated by a mechanical attachment on the inside of the safe door. A locking bar is moved so that the door has a slight play. It is then given an in-and-out movement by means of a cam leverage on the outside of the door. This works the attachment and unlocks the strong bolts. It is arbitrary in its action, not depending upon springs or weights.

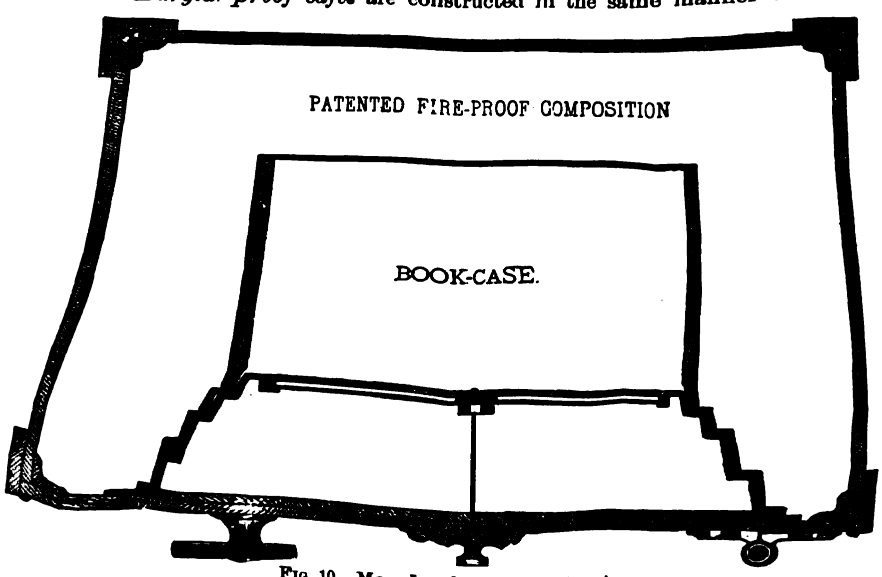


Fig. 10.—Marvin fire-proof construction.

Among the late improvements in safe manufacture, applied by Messrs. Herring & Co., are a new form of hinge, by which the tongued and grooved door is withdrawn perfectly square and true from the jambs in the body of the safe until it is free from the groove with which it interlocks. Safe bodies are made of solid hard and soft steel, or steel and iron welded plates

Another type is known as the bracket machine, being designed to attach to a wall or post. There is a bracket bearing a vertical pulley spindle, and a hinged arm, the outer end of which has a vertical spindle, on the lower end of which there is a drum covered with sandpaper upon its lower head. The rotation of the sandpaper drum, and the traverse of the hinged arm in every direction in a horizontal plane, enable the machine to cover the entire surface of a door, or similar plane piece, and at the same time do work that is reasonably free from scratches. The sandpaper disk is vertically adjustable to different thicknesses of stock, and has a spring handle to regulate the pressure on the surface, and a suction fan to carry away the dust. Another form of this machine has, instead of a bracket, a column placed near a cast-iron table, upon which the door or other piece is placed, and the hinged arm has more joints. In the column is placed the exhaust fan.

Another machine has a single vertical spindle, bearing a plain cylindrical drum or tube of small diameter, covered with sandpaper on its convex surface, and is useful for finishing the internal and external curves of scroll-sawed work. The spindle in the best of such machines moves automatically up and down by a crank and pitman, as it rotates, so as to free the surface of the work from scores. A development of this type has two such spindles, placed about 3 ft. apart, and one bearing a large and the other a small cylinder or tube, these working in curves of either large or small radius. In these, each spindle has a vertical reciprocating as well as a rotary movement; the former being produced by cranks at each end of a shaft, running across the frame at the bottom of the spindles.

A triple-drum sandpapering machine, shown in Fig. 2, is for sandpapering planed sur-

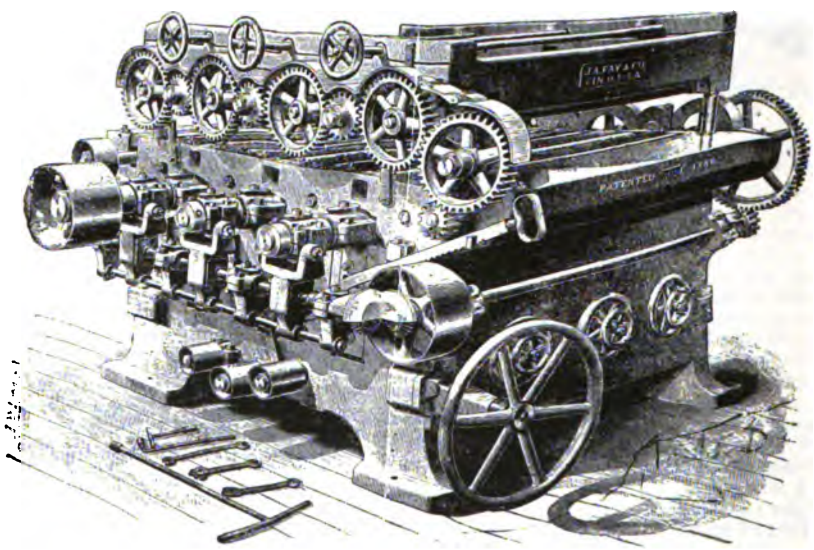


Fig. 2.—Triple-drum sandpapering machine.

faces for furniture, pianos, etc., where the work is to be varnished or painted. There are three drums, made of steel, on which the sandpaper is placed, its grade being according to the work to be done. The first drum carries coarse paper, the second a fine grade for smoothing, and the third a finer grade for polishing. Each of these drums has lateral oscillation across the material, to prevent the formation of lengthwise scores, which would be the case if the material moved straight, and the rolls had no such endwise vibration. The feed rolls are eight in number, four above and four below the platen, and are driven by a train of expansion gearing. They are so placed that the material will pass between the upper and lower sets, and open to receive material 8 in. thick. The lower rollers are placed one each side of the drum, each roller being in a separate bed-plate, which is adjustable with the roller, and the roller has a separate adjustment from the bed-plate. Each bed-plate can be set to gauge the amount of cut to each drum, or all the bed-plates can be set in line, and the drums set to the cut desired above this line. The upper rollers are mounted in a frame over the corresponding lower rollers. The pressure rolls are three in number, one over each drum, to hold the material firmly to them, and are separately adjustable by hand wheels in front, which operate worms and worm gears.

There has been produced one machine which will joint and sandpaper the meeting rails of sash. The sash is placed on a movable carriage, with the meeting rail resting against adjustable stops, by which a heavy or a light cut may be obtained, as desired. The sash while passing through the machine is held in position by springs, by which means the meeting rails are worked to the same thickness. The jointing is done by a rotation cutter head on the vertical axes of one side of the machine, and the sandpapering head or drum is borne by a

angular hole. The one feature of this machine is that in making stock work, where it is uncertain whether the sash will be used with or without cord, the groove can be discontinued at the meeting rail without cutting through it, and this part done by hand if the sash is finally used with cord.

The increasing demand for sash and doors all ready to hang has brought out machines for preparing sash to receive the weight cord in a manner to suit the requirements of all markets; the old method of a groove in the side of the sash, running through a hole that carries the knot on the end of the cord, often being very unsatisfactory. In the machine made by the H. B. Smith Machine Co. there is a table-like frame, bearing along one of its sides a horizontal boring spindle, and having a sliding frame to receive a sash and feed it up to the spindle. A double saw borne by a vertical arbor about the center of width of the machine, cuts a groove which extends into the top or first hole previously bored by the bit, and the work is then completed by the horizontal boring bit, making a hole between the two holes first bored, thus uniting the second or lower hole to the groove. The cord may be very readily passed into this hole, with no chance of getting out after the knot is tied.

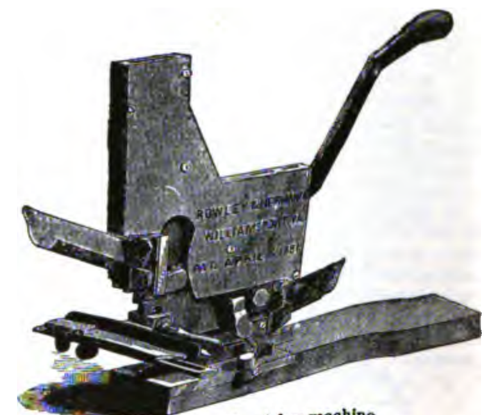


FIG. 2.—Sash wiring machine.

The same machine may be used as a light saw table, with horizontal boring attachment for general purposes; and by using a routing bit in the vertical spindle, blind-rails may be scored for the roller bar.

A machine for wiring both blind-rods and their slats at one operation is shown in Fig. 2. The slat is placed on the upper bed, and by an upward motion of the lever the staple is driven in. Then the same slat is placed on the lower bed, and a downward motion of the same lever staples the slat to the rod. The staple cut-off is so arranged that two staples cannot get under the driver at the same time.

Saw Gummer: see Grinding Machines.

Saw, Pile-cutting: see Pile Driving.

SAWS, METAL WORKING. *Cold Saw Cutting-off Machines.*—Sawing machines for cutting iron, steel, and other metals while in a cold state have come into use during the past few years. They are probably more commonly used in Europe than in this country at present, but

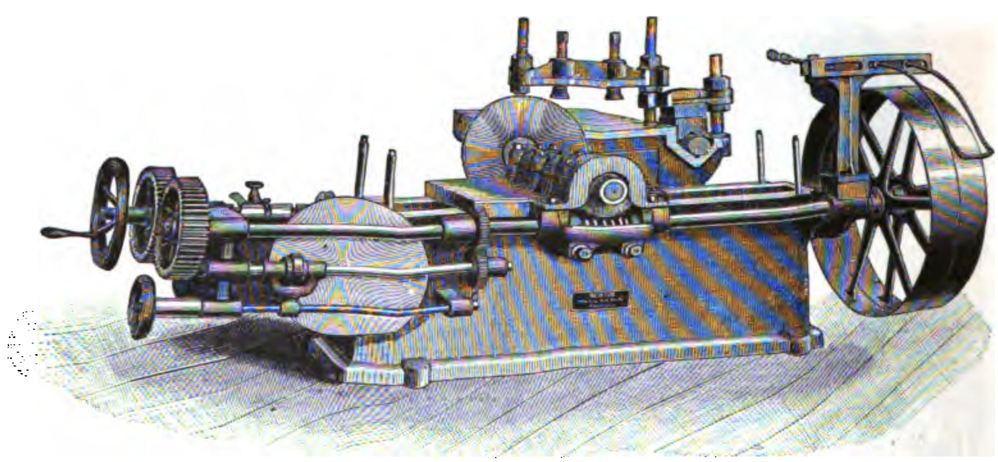


FIG. 1.—Cold saw cutting-off machine for bars and beams.

the Newton Machine Tool Works, of Philadelphia, have recently put on the market a full line of these machines of various styles, and their more general use may be anticipated. Several styles of cold saw cutting-off machines built at the above-named establishment are shown in Figs. 1 to 4.

Circular Saws.—Fig. 1 is a machine designed to cut off round or square bars up to 4 in., and beams up to 16 in. in depth. The saw or mill cutter is 18¾ in. in diameter. It has a variable automatic feed, ranging from ½ in. to 1½ ins. per minute, with power quick return, with automatic stop in both directions.

orizontal Circular Saw.—Fig. 6 represents a cold sawing machine, designed by Messrs.

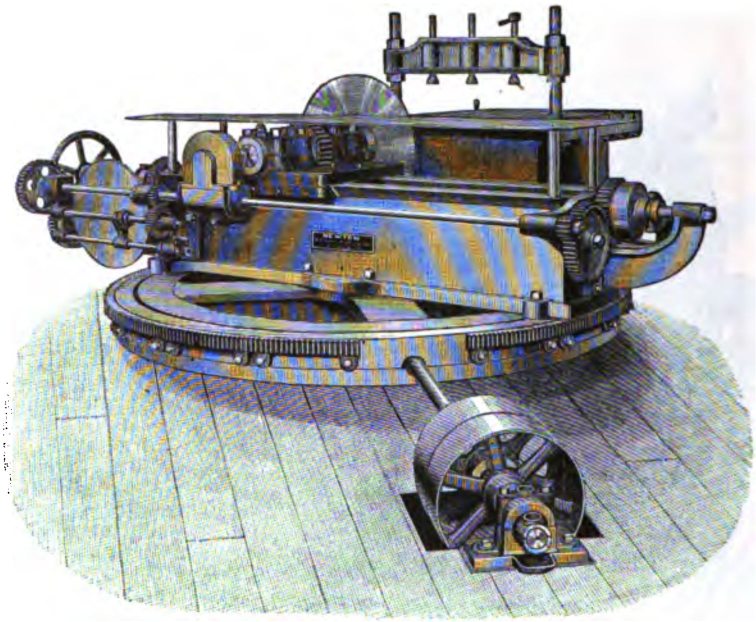


Fig. 3.—Cold saw cutting-off machine built on revolving bed.

& Son, Derby, England, and used principally for the sawing of runners or gates
stings. The saw is caused to revolve in a horizontal plane, and in the case of the

Fig. 4.—Cold saw cutting-off machine.

ed it may be raised to 3 ft. 6 in. The machine carries a 28-in. diameter

› lubricate and cool the saw. The upper wheel is provided
attached weight to keep the saw at a proper tension. The

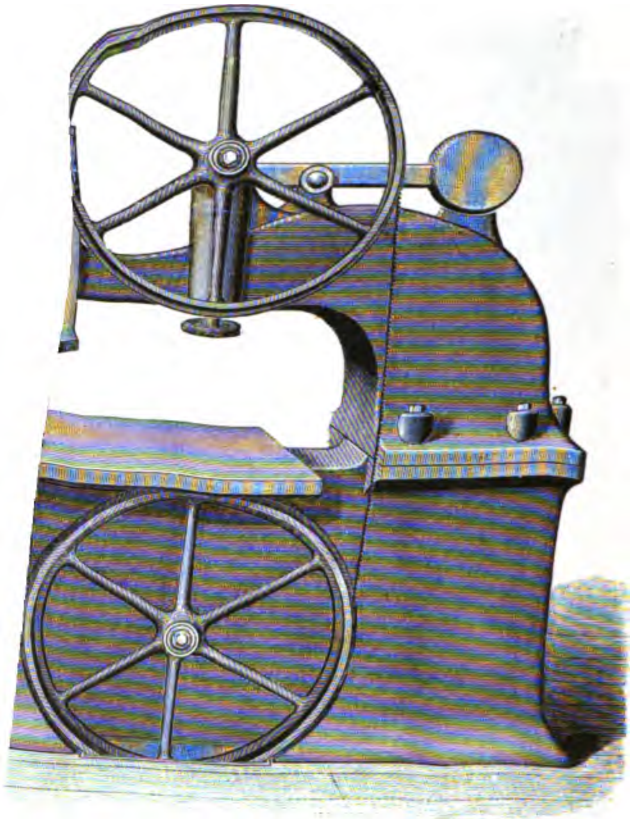


FIG. 7.—Band saw.

ies and presses against a wheel which revolves with the saw.
The lower saw guide is inserted in the table, and the upper
rered to suit the various depths of work.
consideration of sawing machines, we may divide them into
; the former being either strained or unstrained; the circular

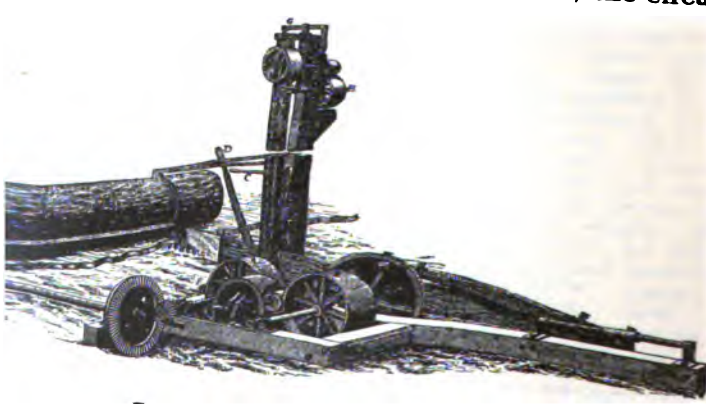


FIG. 1.—Drag-saw and jack-works.

r at this time in addition to what has been said about them
t there may be noted a combination of drag-saw and log-jack

rack that engages with a pinion by which lengthwise feed of the carriage and log are given, driving the saw through the log.

In some mills this rack-and-pinion feed is dispensed with and a rope feed is used; in others the carriage is connected to the piston-rod of a long steam-cylinder, and admission of steam drives out the piston and forces the carriage along by direct action at a marvellous rate of speed; this constitutes what is known as a "shot-gun feed." Lengthwise of the carriage, on the side furthest from the saw, is what is known as the set-beam, which is prevented from springing up by suitable projections engaging with the under sides of the cross pieces of the carriage. To this set-beam there are attached the various head and side blocks and uprights to which the log is attached or against which it rests. The set-beam, blocks, uprights, and log are given traverse across the carriage by slight advances each time that the saw has made a cut and the carriage is drawn back; the rate of withdrawal being much more rapid than that of feed, even with the shot-gun feed. The set-beam is advanced only a slight degree after each cut; and in large mills it is retired by power to make room for the next large log after one has been sawed down to the last board.

The rack-and-pinion carriage feed has the disadvantage that the teeth of the rack and pinions are liable to break, causing annoyance and delay. To lessen this trouble, it is necessary to increase the width of face of the gears, which of course adds to the weight of carriage. Where rope feed is used, there are several ways of effecting the winding up of the rope. In one of them, which may properly be called a rope and gear feed, the rope sheave is made in the form of an internal gear, having the cogs or teeth on the inside and the spiral groove for the rope outside. This sheave is keyed to a short shaft, which runs in boxes bolted to the timbers underneath the carriage and directly opposite to the mill frame. It is rotated by a feed pinion which runs in the internal gear in the same manner as it would in the rack of the carriage.

Some sawyers prefer trucks on the carriage and tracks on the floor, but this has disadvantages, in that tracks on the floor obstruct the floor itself, and dirt on them is readily accumulated and is likely to throw the carriage off the track or lift it on one side, thus making an irregular cut. A carriage with the track on its under side is lighter than one bearing trucks; it runs more easily; the rolls may be more readily kept in line and level than a track; the chairs which bear them may be set on a level with the floor of the mill, enabling it to be crossed with barrows, etc.; they are more durable, because only such rolls as the carriage passes over rotate, while where they are on the carriage every one turns; they are more readily replaced when worn, and are more economical, because when those opposite the saw frame, which are most used, are worn, they can be exchanged for those nearer the ends; and the back rolls being finished the same as the front ones, can be changed to the front and made to do service as guide rolls.

In the best mills the head blocks and horizontal rests on the carriage are at intervals of 3 to 4 ft. the entire length of the carriage, and uprights which add side support are placed on the set-beam directly over, and at right angles to, the head blocks. This arrangement does away with the necessity of moving the head blocks when sawing logs which vary in length.

Saw-mill Attachments.—Dogs for holding the logs are sometimes merely steel rods, having heads like pointed hammer-heads, one end of the rod being fastened by and on to the set-beam, the other end being driven into the log. But those on head blocks and tail blocks are more complicated, being arranged so that two of them bite into the upper and under surfaces of the log in opposition to one another, being forced in by screw or eccentric motion. For enabling the saw to work close up to the uprights, there are what are known as last-board dogs, which project only about one-half inch from the uprights, and may be used after the other dogs have been retired by reason of the log having been nearly entirely sawed away.

A saw-mill dog, brought out by the Knight Manufacturing Co., of Canton, O., belongs to that class in which an adjustable head carries the dog-bit, and is secured at any point on a horizontal sliding bar, with a lever connection to force it into the timber. The upright is formed of two parallel straight pieces, on one of which slides the head carrying the upper dog-bit, giving adjustability in height; the locking mechanism for this being an eccentric and lever. The lower dog is inclined at an angle of about 45° with the vertical, its lower end being turned up to about the same angle. It is controlled by the lever which operates the upper dog. The lower dog-bit moves upward until it strikes the timber, then upward into it, both dogs being locked in position when first in the timber. To operate the upper dog, the dog-bit is dropped on the log, and is forced downward into the timber by drawing downward upon he long lever. When released from its bite in the timber, the lower dog returns to its original osition, automatically locking itself, and remains there out of the way until again liberated y the operator. These dogs are made right and left-handed. For a right-hand mill a right-and dog is used on the front head block, and a left-hand one on each rear block; while on a left-hand mill a left-hand dog is used on the front head block and a right-hand on the rear.

For holding quartered logs on the carriage there are employed what are known as quarter-g dogs, which have two sets of teeth, sliding up and down on the upright, and each set ar-anged so that their points come in a vertical line, inclined about 45° to the horizontal, so hat they can conveniently grip between them the corner of a quarter log, included between ne of the sawed faces and the bark.

For rolling heavy logs on to the saw-mill carriage, and for turning them when slabbing, is almost necessary to have a canting machine of some sort or other. One of the most mple, which may also be used for drawing logs into the mill, consists merely of a horizontal

which is so pivoted that an arm from it extending up through the bed, and connected with a scale of distances, may be moved in either direction, thus giving any desired throw to the feed, and in either direction. The feed-dog is regulated in height by the nut, *D*. *E* is a thumb-nut to secure the arm wherever located. *F* is a thumb-nut to fasten the stop, which secures uniformity of stitch, whether feeding forward or backward.

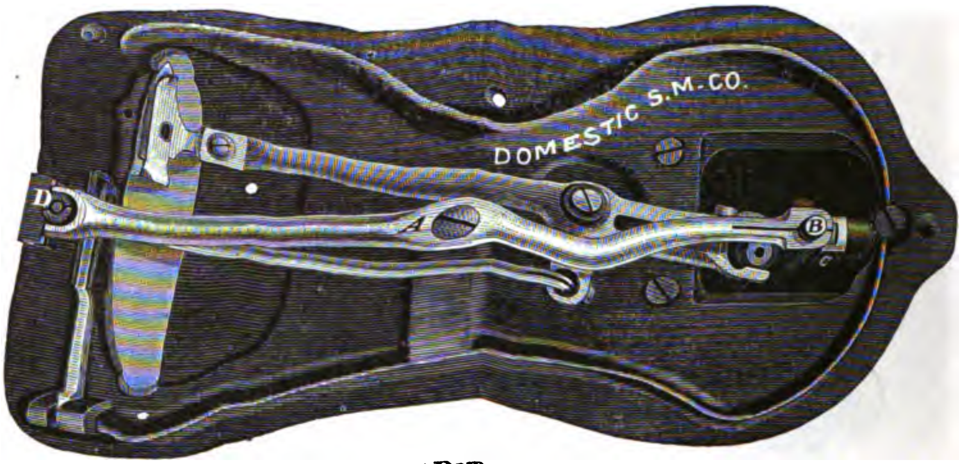


FIG. 6.—"Domestic" machine.

The Willcox & Gibbs Machine in its latest form is represented in Fig. 7. As the parts are all named on the engraving, detailed reference is unnecessary. It has novel means for regulating the tension and the pressure on the material, and for altering the length of stitch.

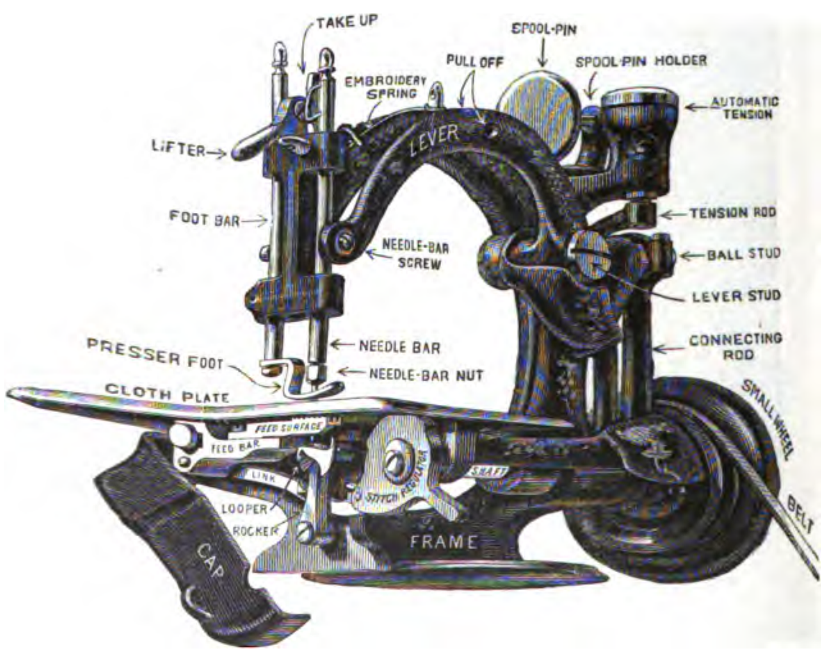


FIG. 7.—Willcox & Gibbs machine.

Combined Lock and Chain-stitch Machines.—A novel machine of this class, illustrated in Fig. 8, is made by the Domestic Sewing Machine Co. A chain stitch looper is substituted for the shuttle, and is attached to the carrier. The second loop is carried around the hook and upon the arm of the looper device, where it is slightly retarded by the tension spring. As it passes off the arm it forms the stitch.

Chain-stitch Machines.—The mechanism of a new machine of this class made by the Singer Co. is shown in Fig. 9. The stitch is formed from a single thread which is inter-

the figure. The axis of the driver is also eccentric to that of the loop-taker, so that, by reason of this eccentricity, the necessary openings for the free passage of thread between the

FIG. 11.—Bobbin.

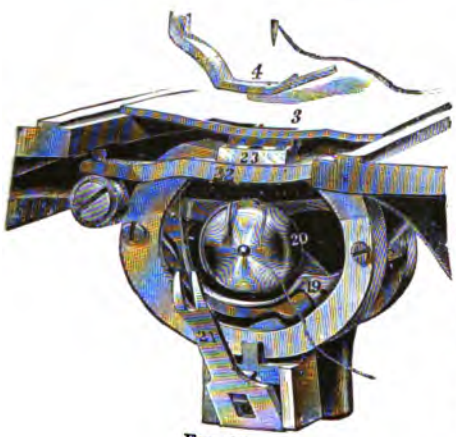


FIG. 12.—Bobbin case.

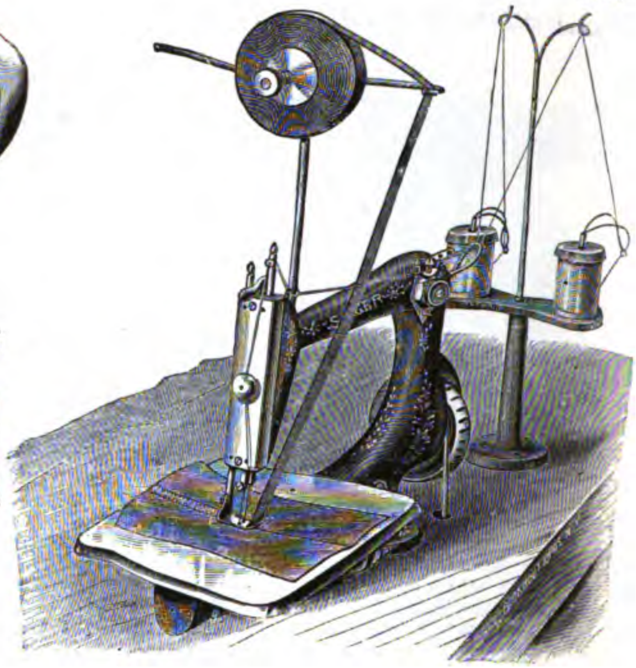


FIG. 13.—Two-needle machine.

driver and the loop-taker are alternately formed at either end of the driver. By this arrangement the loop of upper thread is carried around the bobbin of lower thread without meeting with any resistance. Fig. 11 shows the large bobbin of this machine, and its case, with adjustable tension spring. Fig. 12 shows the bobbin case in the loop-taker, with the bobbin-holder thrown open. The automatic thread controller is actuated by the presser-foot through the medium of the presser-bar, so that the controller gives automatically more or less spread, according to the varying thickness of the goods. This machine is provided with a knee presser-lifter, by means of which the operator can at any time raise and lower the presser-foot by a movement of the knee, leaving both hands free for manipulating the work.

The Willcox & Gibbs Straw-hat Machine makes practically a concealed stitch. It has a claimed capacity of 1,000 hand stitches per minute. It produces all sorts of plaits, from the coarsest "rough-and-ready" to the finest "Florence" Milans." This is secured by compensating action between the threader, looper, and presser-foot, whereby the needle automatically adapts itself to the thick-

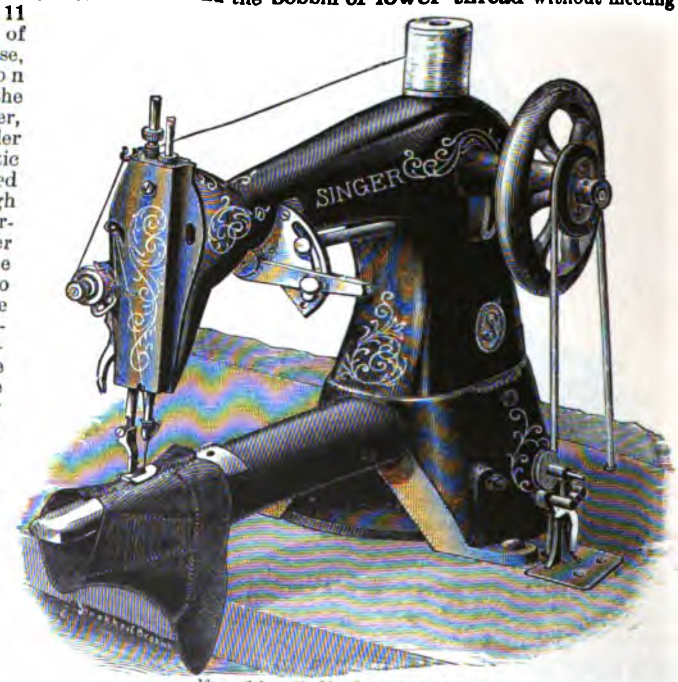


FIG. 14.—Cylinder machine.

machine made by the Singer Manufacturing Co. It has oscillating mechanism. On the front of the arm is a slotted lever, worked by a cam within the arm. Hinged to this lever is a pitman connected at the reverse end with a rocking frame, through which the needle-bar operates. The pitman communicates the to-and-fro movement of the lever to the rocking shaft, thus giving the needle-bar the same movement, which may be extended or entirely thrown off by altering the adjusting thumb-screw seen in the cut. This machine is used for sewing cloth, leather, carpet, or knit goods, binding, and especially for overcasting the raw edges, left over after seaming up.

Carpet-sewing Machines.—The machine shown in Fig. 16, and made by the Singer Co., comprises the latest improvements in machines used for this purpose. It is fitted with a saddle device, so that it rides upon the edges of the carpet. The carpet to be sewed is

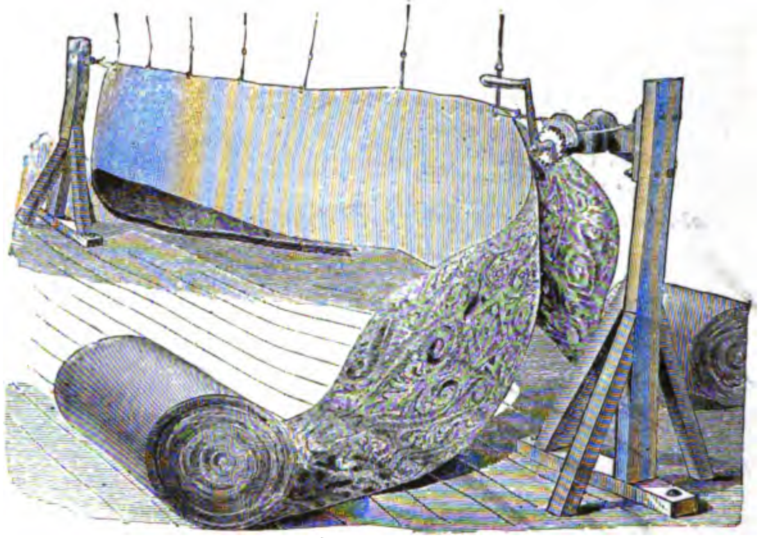


FIG. 17.—Two-needle carpet sewing.

suspended, edge up (Fig. 17), between two clamps attached to upright posts, one of which is stationary, and the other fastened to a windlass, by which the carpet is stretched taut. The saddle is placed on the tightly-drawn edges. With the left hand the operator grasps the handle shown in cut. The machine, as it is operated, feeds itself along the edges of the carpet. The character of the stitch permits the opening of the carpet flat while retaining a complete union of its edges.

The 16-ft. canvas and belting sewing machine, designed by the Singer Co., is probably the largest sewing machine ever built. It has an oscillating shuttle, two needles, and will stitch goods from ⅛ in. to 1 in. in thickness, and any width to 7½ ft. It is fitted with roller feed, and a guide adjustable for various widths, for making parallel seams.

See also BOOK-BINDING MACHINES and LEATHER-WORKING MACHINES.

Shaft-rounding Machine: see Molding Machines, Wood.

Shaper: see Molding Machines, Wood.

SHAPING MACHINES, METAL. *The Hendey Traverse Shaper.*—Fig. 1 shows a heavy shaper built by the Hendey Machine Co., Torrington, Conn., and designed for railroad and other heavy work. It has a stroke of 30 in., and can be set to vary length of stroke while in motion. The saddle has a traverse on the bed of 72 in. Feed works at each end move the saddle back and forth. The saddle can be run fast by hand from one end to the

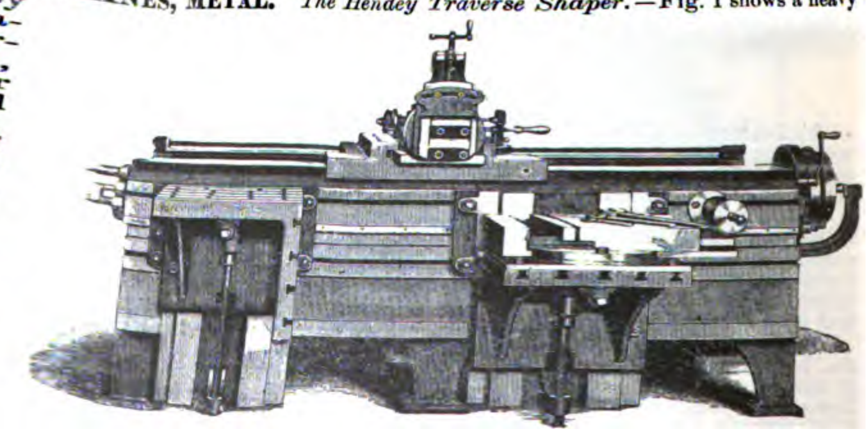


FIG. 1.—The Hendey traverse shaper.

but the top plate is hinged at the rear end of the open table, and is raised by the screw shown, and is clamped when in position by screws passing through slots in the drop pieces shown on the under side of the plate.

Sheaf Carrier: see Harvesting Machines, Grain.

SHEEP-SHEARING MACHINE.—Fig. 1 shows the sheep-shearing machine of Burgon & Boll, Sheffield, England, installed complete; Fig. 2 shows a few links of the flexible operating chain; and Fig. 3 is a larger view of the shears. The fly-wheel when in gear actuates the friction wheel, marked *c*, fitted with a spindle having a gimbal joint at its base to connect it with the flexible chain, which is contained within a hempen tube. Another gimbal joint at the lower end of the chain unites it with the shears, which are like those of a horse-clipper and formed to be held in the hand of the operator. The under teeth of the shears, ten in number, remain stationary, while three upper teeth reciprocate rapidly upon them, something like two thousand times per minute. With

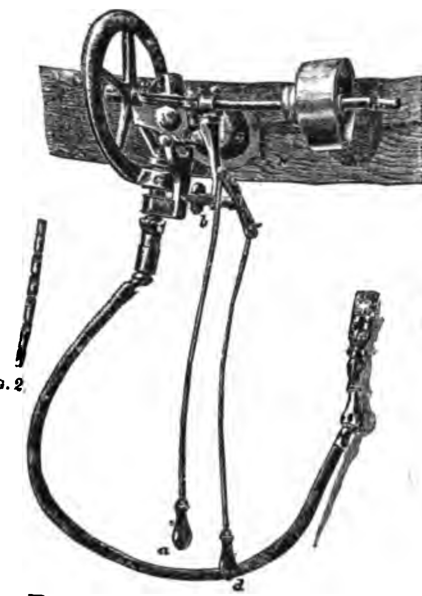


Fig. 2

Fig. 1.—Sheep-shearing machine.

Fig. 3.—Detail.

the machine it is easy to avoid cutting the skin of the sheep, while gaining more wool and working more rapidly than with hand work. The hanging cords, *a* and *d*, are for starting and stopping the machine by means of the shifter, *b*. The flexible chain is of hardened steel.

SHINGLE-MAKING MACHINERY. In the manufacture of shingles nearly every machine, except for jointing the butts, is a sawing machine; the difference being as to whether the saws are on vertical or horizontal arbors, and whether one saw takes care of one or more than one block. Machines with two or more saws cut from four to ten bolts at one time. The machines of smaller capacity usually present the bolt to the saw and withdraw it by a reciprocating motion, those of larger capacity using a rotary motion. Among the former, the principal points of difference are as to whether the block is presented end on or side on; and in minor details of varying the taper, thickness, etc.

For making sawed shingles there are several classes of machines. One of the most simple has a circular saw upon a vertical arbor, belted from below, and a sliding carriage presents the bolt endwise to the saw, so as to cut with the grain of the wood instead of across it. This table or carriage has an adjustment by which either the front or the back end may be tilted, so as to saw a shingle which is tapering in its length; and there is provision for changing the thickness of cut without altering the taper, or for varying both. Such a machine will cut 3,000 to 4,000 cedar shingles per hour; and it is also adapted for sawing heading and box stuff.

In the shingle machine made by Adams & Sons the saw arbor is vertical, and the block or bolt is borne between dogs at the end of an arm vibrating in a horizontal plane and presenting the side of the block to the action of the saw. The taper is given by tilting one end of the table bearing the block by a foot lever; this gives the requisite degree of taper to one shingle, and the table being brought back by a spring when the foot is taken off the treadle after one shingle is cut, the next shingle is cut with the butt coming at the opposite end of the bolt from that of the first one cut. Thus every other shingle has its butt to the right; and the saw cuts slanting at every other cut, and parallel on the intermediate cuts.

A shingle and head-cutting machine brought out by S. Adams & Son has the axis of the circular saw which does the cutting inclined slightly from the vertical, and the top or table is semi-circularly inclined from the horizontal. Along the top there slides a clamping table which holds the bolt which is to be cut; the bolt being placed crosswise of the machine so that its side is presented to the action of the saw. The bolt being clamped at the lower end of the inclined table, every time that the table is drawn forward the shingle or heading is sliced from it, and drops clear of the saw. There is suitable adjustment for giving any thickness or degree of taper, and the machine will cut with the butt first on one end of the block and then on the other, or may be set so as to cut the butts continuously from either end, as desired. The capacity claimed is 3,000 shingles per hour from suitable blocks, or 60 shingles per minute from blocks 8 in. wide. The carriage is moved up over the saw by a pinion running in a rack gear until the saw has passed through the block, when the pinion is automatically released and the carriage moves back by gravity. Then the dog opens, the bolt or block drops on the platform, which is tilted by a ratchet wheel, the pinion engages the rack

twelve radial plates, in the shape of an immense fan wheel. Upon the front of these radial plates are placed an inner and outer series of knives. These knives are pivoted on radial pins, and the surfaces of the knives being inclined to one another, the knives are canted when they encounter snow, and are set so as to slice the snow off the bank on to the fan, the centrifugal force of which causes the snow to fly to the outside of the fan-wheel, and as the latter is surrounded by a casing, the snow can only escape when an opening is provided for it. This opening is at the top of the wheel, immediately behind the headlight. The opening is provided with a movable hood, so that the stream of snow can be regulated and made

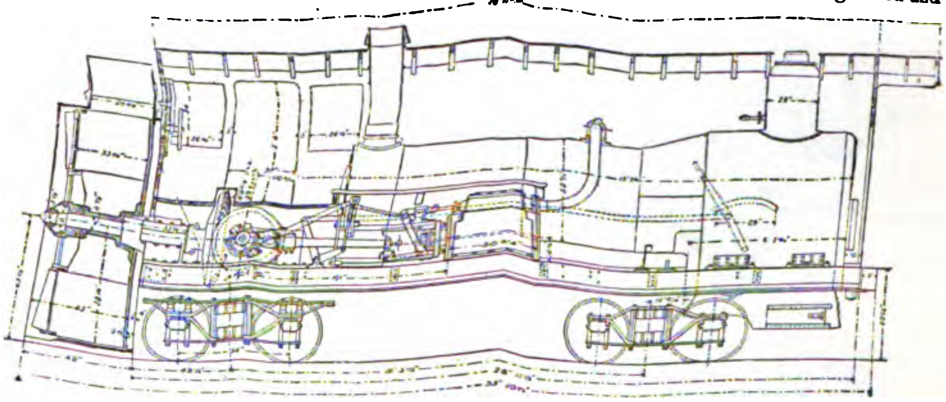


FIG. 1.—Leslie rotary snow shovel.

to fly either to the right or left of the track, and at any desired angle. The rotary, when in operation, is in the charge of a pilot, who stands on the platform in the front end of the cab, from which he has a full view ahead, as well as on each side of the track. By a system of signals he controls the engineers on the rotary and locomotive which pushes it, and by a hand wheel can alter the position of the hood that directs the stream of snow to either side. He has also charge of the ice breaker and flanger for cleaning the rails and flanges after the main body of the snow has been removed by the rotary.

The ice breaker is a stout plate of steel, hanging in front of the front wheel of the front truck, and so attached to the journal box and frame of the truck that it rises and falls with the

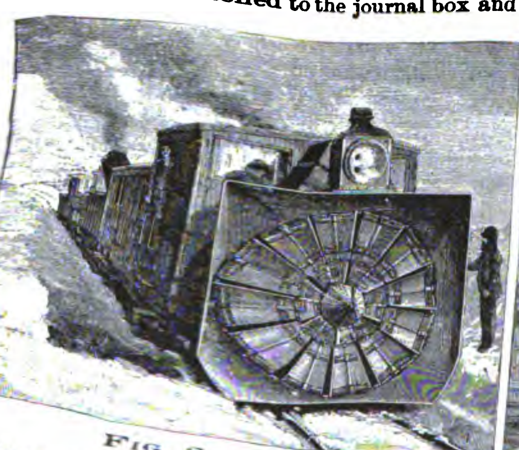


FIG. 2.—Elevation.

FIG. 3.—Shovel at work.

movement of the front truck wheels, and consequently maintains a fixed position about half an inch above the top of the rail. The ice-breaker and the flanger, which follows it, can be raised and lowered by means of a small steam cylinder, which is supplied by steam from the boiler of the rotary. The flanger, which clears out snow from both sides of the rail for a distance of about 12 in., is attached in a somewhat similar manner in rear of the rear wheel of the front truck. Any ordinary locomotive tender can be attached to the rotary for the purpose of carrying water and coal for the supply of its boiler.

The weight of the machine complete is 110,000 lbs. It is in use on many of the largest railroads of the United States and Canada.

Siamese Connection: see Fire Appliances.

Signals, Railroad: see Switches and Signals.

Silicon Bronze: see Alloys.

worm-wheel being in the center of the saddle. The machine will admit work 28 in. diameter and 10 in. in height. The circular carriage is 17½ in. in diameter, and is made very heavy. Both automatic and hand feeds are provided.

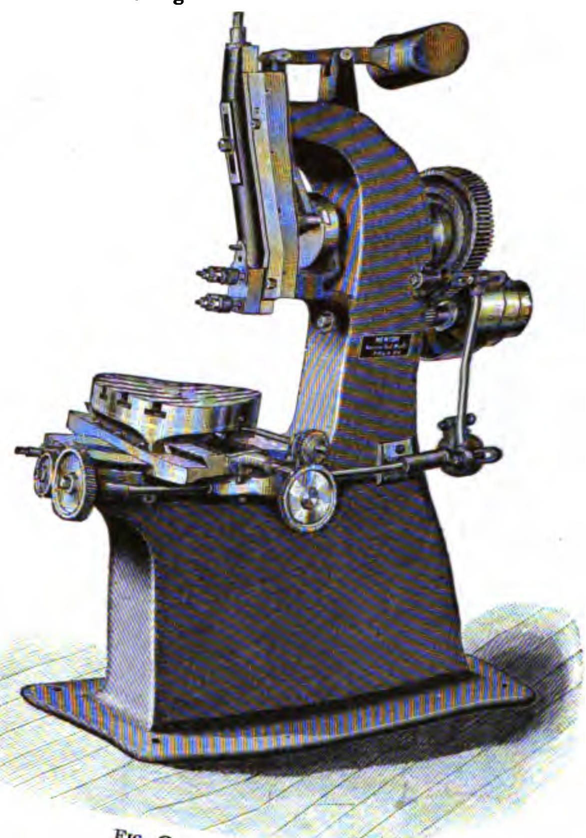


FIG. 2.—Six-inch slotting machine.

SOAP - MAKERS' MACHINERY. There are two well-known processes of soap-making, that by long-continued boiling, and the so-called "cold process." While "cold-process" soap can be made with a much simpler and cheaper plant than regularly boiled soap, it requires a higher grade of stock to make a merchantable article, and as rosin has seldom been successfully used in "cold-process" soap, it is usually cheapened by adding silicate of soda. Of all fillers, sal soda is probably the most satisfactory, as it will soften hard water and does not render the soap so sharp and harsh to the skin as does an excess of uncombined or free caustic alkali. A soap moderately filled with sal soda will generally give better satisfaction than a soap not filled at all. In soap kettles for boiling soap, good practice allows 25 cub. ft. content for every 1,000 lbs. of finished soap the kettle is to turn out in a boiling. While exact data are wanting, it is probably nearly correct to allow one horse-power boiler capacity for every 1,000 lbs. of finished soap to be turned out in a single boiling. A criss-cross coil in the soap-boiling kettle is just as effective and much cheaper than a spiral one of the same heating surface.

A high-grade toilet soap can be made from cuttings and scraps of a *good* quality of boiled soap, by dry remelting to get rid of excessive water. For this purpose the soap stock should have no, or but little, filling. Cuttings and scraps of "cold-process" soap, especially if filled with silicate of soda, cannot be successfully remelted, as the grain becomes coarser. They may be worked up with a new batch of soap, however, or can usually be disposed of to laundries, etc.

The formation of "bags" in "cold-process" soap, it is said, can be prevented by passing a hand crutch back and forth longitudinally through the framed soap several times. After the soap is cut into cakes it is racked and allowed to form a skin by action of the air. Different soaps will require different lengths of time, and the state of the weather will have considerable to do therewith. If possible, select a clear, dry day for pressing, and avoid a clammy, soggy day, as on such days all soap sweats and becomes frothy in pressing.

To prevent sticking of the soap to the dies, it is necessary to sponge the dies or soap in some liquid in which soap is *not* readily soluble. The best way is to sponge the cake on both face sides. For sponging, oil of myrbane and oil of citronella, either singly or mixed, have been used. Salt water, however, is better, and weak acetic acid (vinegar) is best.

Fig. 1 represents a machine for making soap by the "cold process," remelting and crutching soap scraps, melting and mixing rosin, rendering tallow, etc., manufactured by Messrs. H. W. Dopp & Son, of Buffalo, N. Y.

The steam jacket and inner shell are cast in one piece, having a number of stays between the inner and outer shell; there is a large outlet in the center of the bottom for the discharge of the contents. A steam-heating radiator, composed of a series of cylindrically arranged pipes having open spaces between them, is placed in the center; through this radiator steam passes directly to the jacketed part of the kettle, which can be cut off from steam supply so that the inner cylinder only has steam. A conveyor screw is placed in the center of this radiator, which surrounds the screw. As soon as a portion of the soap is melted, the screw is set in motion, thereby lifting the soap up and dumping it over the top of the casing surrounding the screw, when the centrifugal force forces it out of, or through, the open spaces left between the pipes. The large scraps are carried up and are wedged in

lbs. It has a single-acting steam cylinder placed underneath the bed

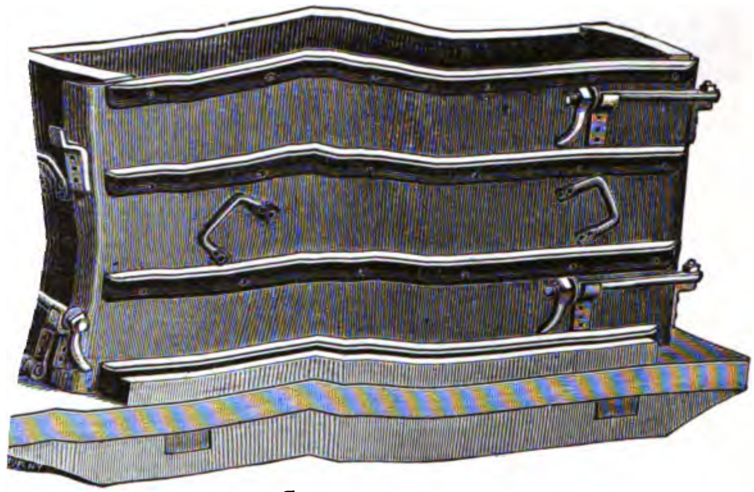
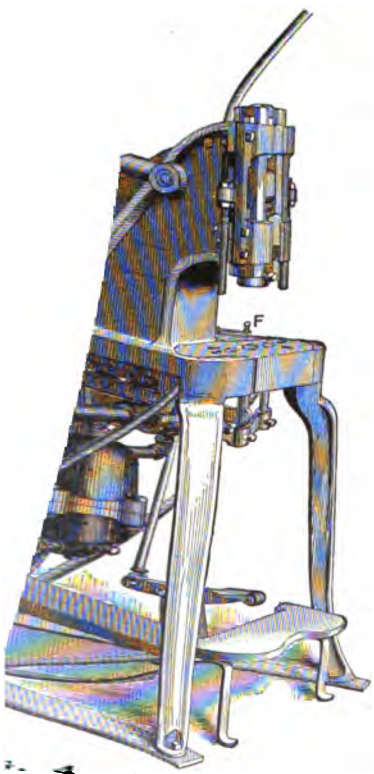


FIG. 3.—Soap frame.

t its piston, by means of a roller attached to the end of the piston rod,



. 4.—Soap press.

acts upon a cam surface of the swing or pendulum lever, as indicated. A hook, attached to the piston rod, engages with a stud on the swing or pendulum lever and prevents the latter from recoiling after having returned from giving the blow, as it can not fly back without pulling out the piston. Thus, vibration of the upper die block is prevented. The steam supply pipe enters a governor or regulator, which can be set by hand wheel, so that the press gives a blow of required force. When this has once been set, the press cannot give a stronger blow than that for which it is set, no matter how much steam pressure the boiler may supply. To the right of this governor is shown a balanced valve steam trap which drains off all condensed water and insures the admission of dry steam only to the cylinder. The admission of steam is controlled by a foot treadle shown at the right of the cut. The handle serves to control the exhaust in such manner that the pendulum lever returns with just enough force to eject the pressed soap and no more. The ejection of the soap is accomplished by a cam, which is pivoted at one end to the pendulum lever, and clamped to the latter by a jam nut and arcs. Against this cam works, by means of a roller, a lever which, with its other end, actuates the center lifting bolt. By unclamping this cam, shifting it up and down, and reclamping, the height to which the soap is lifted is regulated. This arrangement lifts the soap so gradually that there is no danger of throwing the cake of soap out against the upper die block and defacing the impressson, no matter how fast the press is worked. By throwing back hook, and raising the foot-rest, ransformed into an ordinary foot press.

useful works on soap making are: Brannt's *Manufacturing of Soap* Baird & Co., Philadelphia, Pa.; and Gardner and Cameron's *Soap* iston, Son & Co., Philadelphia, Pa.

teadily applied. To relieve the team from undue jerking under the chopping action lescribed, the doubletree is connected by a spring to the draft rod of the machine. The cylnder is covered for safety from the knives, and the cover forms a box for ballast, to add veight when needed to insure thorough cutting. The floating frame and cutters are raised nd held up by a lock lever when not required to cut. The knives are set tangentially ackward, at that angle which insures the best cutting result. The knife-reel is rotated by ontact with the ground as the machine advances. The same class of machine is used on otton land to fit it for the plow by cutting the cotton stalks into short lengths in the same 'ay, but owing to their toughness and hardness is necessarily made much heavier and ith stronger reaction side springs than is necessary for corn-stalks.

Avery's Stalk Cutter, Fig. 2, has six knives arranged spirally around their axis to effect nstant pressure on the ground, and thus avoid jolting; also to distribute the work evenly y cutting few stalks at once; and to lighten work by cutting them obliquely with their ain. The cutting apparatus presents, when viewed from front or rear, a profile as shown Fig. 2, suiting the machine to the usual ridged contour of cornfields. The machine is eferably made wide enough to cut the width of two corn rows, to use two horses and a an, for about as much duty as for four horses and two men with two of the single-row size. he cutters have their axis independent of the ground-wheel centers, and their pressure can controlled by the lever.

Stamp: see *Ore-crushing Machines.*

Stamping Machines: see *Book-binding Machines.*

Stave Jointer: see *Barrel-making Machines.*

Steamers, Passages of: see *Engines, Marine.*

STEAM LOOP. The steam loop is the name given to an ingenious device, shown in Fig. for returning the water of condensation from a steam pipe or separator into the boiler. It nsists merely of a system of piping, and does not necessarily contain any valves, adjustments, or moving mechanism. The following description of its method of operation is extracted from a lecture by Walter C. Kerr before the Franklin Institute. The principles on which its action depends are as follows: Difference of pressure may be balanced by a water column; vapors or liquids tend to flow to the point of lowest pressure; rate of flow depends on difference of pressure and mass; decrease of static pressure in a steam pipe or chamber is proportional to rate of condensation; in a steam current water will be carried or swept along rapidly by friction. The water of condensation runs into

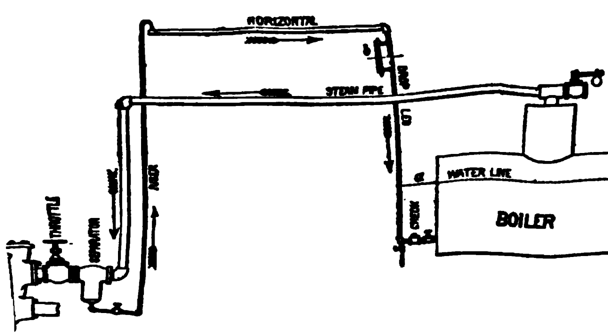


Fig. 1.—Steam loop.

parator. (See cut.) The drip from the separator is below the boiler, and, evidently, were ipe run from this drip outlet directly to the boiler, we would not expect the water to ren up-hill. Moreover, the pressure in the boiler is, say, 100 lbs., while in the separator it nly 95 lbs., due to the drop of pressure in the steam pipe, by reason of which difference steam flows to the engine. Thus the water must not only flow up-hill to the boiler, must overcome the difference in pressure. The device to return it must perform work, in so doing heat must be lost. The loop, therefore, may be considered as a peculiar or doing work, the heat expended being radiation from the upper or horizontal portion. m the separator or drain leads the pipe called the "riser," which at a suitable height ties into the "horizontal." This leads to the "drop leg," connecting to the boiler anyre under the water line. The "riser," "horizontal," and "drop leg" form the loop, and ally consist of pipes varying in size from $\frac{3}{4}$ in. to 2 in., and are wholly free from valves, loop being simply an open hole from separator to boiler. (For convenience, stop and k valves are inserted, but they take no part in the loop's action.) Suppose steam is ing, engine running, and separator collecting water. The pressure of 95 lbs. at separ extends back through the loop, but in the drop leg meets a column of water which risen from the boiler, where the pressure is 100 lbs., to a height of about 10 ft.—that o the hydrostatic head equivalent to the 5 lbs. difference in pressure. Thus the sysis placed in equilibrium. Now, the steam in the horizontal condenses slightly, lowerthe pressure to, say, 94 lbs., and the column in drop leg rises 6 in. to balance it; but nwhile the riser contains a column of mixed vapor, spray, and water, which also tends se to supply the horizontal as its steam condenses, and, being lighter than the liquid r of the drop-leg, it rises much faster. If the contents of the riser have a specific ity of only ·1 that of the water in the drop leg, the rise will be ten times as rapid. when the drop leg column rises 1 ft., the riser column will lift 10 ft. By this process iser will empty its contents into the horizontal, whence there is a free run to the leg and thence into the boiler. In brief, the above may be summed into the state-

the furnace, is placed checker-work of fire-brick, supported on tiles (*28*), so that the bottoms of the flues are clear openings, giving a stronger draught; but as there is constant tendency of the heated air to ascend, there is a thoroughly uniform heating of the air entering the furnace by this arrangement. The front portions of the flues are provided with a series of double arches. The four-way chamber (*25*) has the air duct (*26*) leading into it permanently open, and is fitted with a three-way valve (*33*), alternately connecting the flues (*22–23*) leading to each end of the furnace with the chimney (*21*) and with the air chamber (*25*), in this way reversing the furnace on the well-known Siemens principle. This three-way valve (*33*) is hollow, and is kept cold by a stream of water running through it, preventing the warping or burning out of the valve, or with the Siemens gas furnace, the direct loss of fuel by leakage to the chimney. The tap-hole of the melting furnace is at about the ground-level, and the metal is conducted, through an inclined spout some 10 ft. in length, to the ladle pit (*27*). The Lash furnaces have all the ordinary and important operations around the furnace on one ground level, the three doors on the back side of the furnace and the two on the front or tapping side being accessible for charging or for repairs to the furnace. A record of 500 consecutive heats, of 50,000 lbs. of stock each, shows that these were charged in an average of 24 minutes per charge, 12 men, or all hands about the furnace, doing the charging from all five doors, which are balanced and arranged to open by levers in the pulpit under the control of the crane boy.

The Batho Furnace is represented in Figs. 4 to 7. It consists of five separate wrought-iron cases, all on one level, lined with fire-brick, which form the outside walls of the four regenerators and of the melting chamber. The regenerators are connected to the melting chamber overhead by means of wrought-iron pipes, running almost horizontally, which are lined with refractory material. The melting vessel is lined with basic material and covered with a roof of silica brick, enclosed in a strong skew-back ring of iron. The gas ports are in the side walls of the melting chamber and the air is carried in through a port in the roof directly over

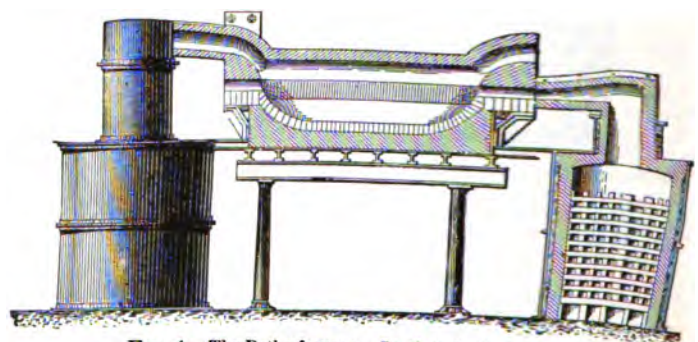


Fig. 4.—The Batho furnace. Sectional elevation.

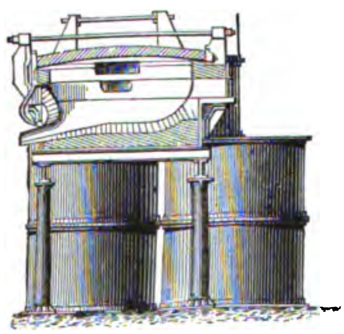


Fig. 5.—The Batho furnace. Cross section.

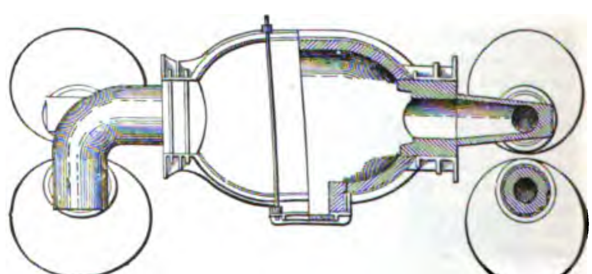


Fig. 6.—The Batho Furnace. Plan.

the gas entrance, the air port having a very steep pitch into the furnace of at least 8 in. in every foot. This arrangement guides the flame downward right on the hearth, and does away with much of the sharp cutting action of the flame on the roof, which thus has to stand the reflected and radiated heat only. The basic lining is separated from the acid by ¼ to ½ in. only of neutral material in the form of carbon brick or chrome ore. The upper 18 in. of the lining walls of the melting chamber are of silica brick. The Batho furnace is well adapted for the basic process on account of the facility of getting at and replacing the linings. (See "Recent Improvements in Open-hearth Steel Furnaces," by A. E. Hunt, Trans. Am. Inst. Mining Engrs., Vol. XVI.)

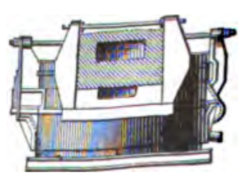


Fig. 7.—End elevation.

Open-hearth Practice in Europe.—Mr. F. Lynwood Garrison, in his report on

s follows: phosphorus ranging from 2·62 to 2·93 per cent. Manganese, 1·15 to 2·97 t.; silicon, 0·11 to 0·31; sulphur, 0·035 to 0·086, the percentage of sulphur before urization being 0·100 to 0·481.

Robert-Bessemer Converter, Fig. 8, is described in F. Lynwood Garrison's report on the Metallurgical Arts at the Paris Exhibition (*Journal Franklin Institute*, 1890), which see.

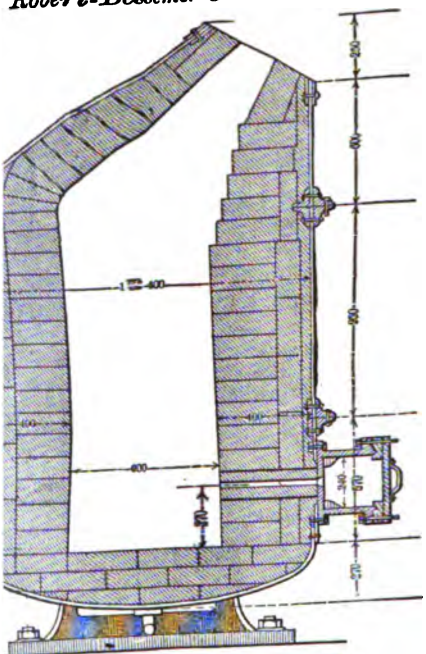


Fig. 8.—The Robert-Bessemer Converter.

What is claimed as novel in the converter is "a combination of several parts in a converter having a flat side, in which flat side are ranged the tuyeres in a plane horizontal to the axis of the converter, and all in the same plane." "The tuyeres having an inclination to enable a rotary motion to be imparted to the metal bath, and being so disposed that by tilting the converter in the trunnions the depth of the metal over the tuyeres can be regulated."

It seems to have produced excellent results wherever put in operation and to be the only side-blown converter which is suitable for the basic process, as the large amount of slag produced would soon choke up a similar fixed converter.

Processes for preventing Piping of Steel Ingots.—Recent processes for preventing piping are thus described by Mr. T. S. Crane, in a paper published in the Trans. A. S. M. E., Vol. X. Strenuous efforts have been made, and by many different modes, to prevent the piping of cast-steel ingots, but it is only recently that a simple apparatus has been perfected for practically accomplishing this object.

Some of the most modern means heretofore used are mentioned below. The "Sweet" process consists in putting powdered charcoal upon the top of the ingot when poured, to ent its upper end from oxidation, and, by its combustion, to maintain the fluidity of the , and thus assist in filling the pipe as it forms. The entire effect is very slight. The pression process used by Whitworth to form sound steel ingots has never been wholly essful, as it operated to consolidate the exterior of the casting without permitting the discharge of the gases from its interior; and while it has operated to prevent the formaof a pipe or local depression, it has been liable to produce a spongy or porous casting. ious modifications of Whitworth's plan have been devised. S. T. Williams has devised mpression process for making sound circular ingots for saw plates. The comparatively n and flat form of such ingots permits the sides to be bent or crushed inward, while the rior of the ingot is still at a welding heat, and this effects the desired purpose much better than in a square ingot, where the compression of the sides would tend to induce cracks. he metal, when first crystallized, is not very tenacious. In experiments tried by William Hinsdale, at the Jersey City Steel Works, in the year 1884, it was found that a pressure 300 lbs. per sq. in., operating upon a 24-in. piston, and concentrated upon the end of a 8½-square ingot, merely produced an ingot containing innumerable globules of gas.

The "Billings and Hinsdale" process provided a reservoir at the top of the mold, and a vable plunger within the mold, by which the steel was drawn downward to make an ot, which would be fed during the shrinkage period by the residue remaining in the ervoir. This process is not, therefore, convenient except for the casting of large ingots. . Hinsdale also experimented at the Jersey City Steel Works with a pressure of 60,000 . per sq. in. upon the metal. The result was the shortening of the ingot from 25 to 22 in. length, and perfect solidity, except that the pipe appeared in the same form, a flaw, as it inarily displays itself at the piped end of a forged bar. Mr. Hinsdale thus found that ing, or its effects, could not be eliminated by pressure, and invented a perforated plug to ert in the mold upon the top of the fluid metal, through the perforation in which the es might escape while applying the pressure.

With this device the top of the ingot became slightly chilled, and a crust formed thereon; after the pressure upon the metal was raised to about 20,000 lbs. per sq. in., the crust of tal exploded with a loud report, and a circular piece like a boiler punching shot out of the foration in the plunger, followed by all the gases, and sufficient metal to fill the cavity form a stud as long as one's little finger, on top of the ingot.

This process produced ingots absolutely solid and free from defect, which had been proved ossible by the mere use of pressure. The expense of all these methods, and the inconvence of applying them to the open ingot molds universally used for casting steel ingots, reted in the invention by Mr. J. B. D'A. Boulton, of Jersey City, N. J., of an apparatus in ich ingot molds made without bottom, but in other respects like the common ingot molds,

since December, 1887, and one ingot per minute is cast in it regularly when the heat is ready. The ingots cast are nearly 4 in. square, and are absolutely sound; but the machine is equally adapted to cast larger ingots by making the holder and the ingot molds of suitable dimensions. One man suffices to operate the levers of the hydraulic apparatus, and the ordinary operators are employed to pour the metal.

Mr. William R. Hinsdale obtained a United States patent, dated January 6, 1891, No. 444,381, for a process of forming ingots, which he states consists, essentially, in chilling the surface of the ingot which is last cast in the mold, and which is therefore the hottest, and in reversing the ingot after such surface is sufficiently chilled to exclude the atmosphere from the fluid interior of the ingot.

In this invention the retention of the fluid metal within the chilled shell is absolutely essential, whereas in earlier methods the discharge of the fluid metal is the ultimate object, and the chilling of the top end of the casting before reversing the ingot is carefully avoided. One of the claims of the patent is as follows: The process of forming ingots, which consists, first, in inserting a cup of heated material in the bottom of the mold; secondly, filling the mold; thirdly, excluding the atmosphere from the mouth of the mold; and, fourthly, reversing the mold, as and for the purpose set forth.

Steel Castings.—Fig. 9 is taken from a photograph of a box-slide casting made by the Medvale Steel Co., of Nicetown, Pa., for the 12-in. turret mount for the United States turret ship *Puritan*, in October, 1891. The government specifications under which this casting was made are as follow: Tensile strength, 65,000 lbs. per sq. in.; elastic limit, 25,000 lbs. per sq. in.; extension, 15 per cent.; contraction, 25 per cent. The result of the tests made from this casting showed that the steel possessed the following physical characteristics: Tensile strength, 65,174 lbs. per sq. in.; elastic limit, 31,058 lbs. per sq. in.; extension, 25.10 per cent.; contraction, 35·04 per cent. The weight of the casting was 15,547 lbs.

In addition to the tests above given on the sheet enclosed, the casting was put to a ballistic test, to determine the ductility of the metal. This test is made by subjecting the pieces to the fire of rapid-firing guns at short range, and the castings are accepted if it is shown by this test that they can be bent or perforated by projectiles fired from these guns without breaking. Ordinary steel castings, if put to this test, are apt to fly to pieces at the first discharge, thus making the gun sought to be shielded useless, and probably causing much loss of life. The combination of high elastic limit, extension, and contraction in the casting illustrated, indicates that it would withstand an immense amount of battering without going to pieces, and that it is particularly well suited for the purpose intended. What is chiefly remarkable about this casting is, that while the tensile strength developed is but 174 lbs. above the government requirements, the manufacturers succeeded in increasing the elastic limit by 24·2 per cent., the extension by 67 per cent., and the contraction by 40 per cent. beyond the requirements. That this was not an accidental performance was shown by the fact that subsequent castings from the same pattern have shown in the average fully as good results.

Stem, Cotton Picking: see Harvester, Cotton.

Step: see Water-wheels.

STOKERS, MECHANICAL. *The Roney Mechanical Stoker*, Figs. 1, 2, and 3, when

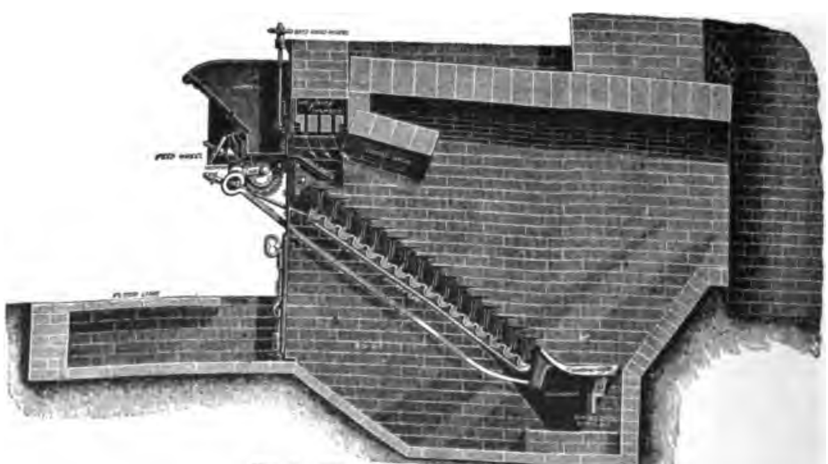


FIG. 1.—The Roney mechanical stoker.

attached to steam boilers, receives the fuel in bulk, and feeds it continuously and at any desired rate to the furnace.

The fuel to be burned is dumped into the hopper on the boiler front. In small plants it may be shoveled in by hand. In large plants it is usually handled direct from the car to the hopper by elevators and conveyors. Set in the lower part of the hopper is a pusher, to which

after experiments with various metals, Planté decided upon the use of lead plates in dilute sulphuric acid, because in discharge both plates were active; that is, not only did the peroxide of lead plate combine with hydrogen, but the reduced metallic lead combined with oxygen. *Planté's cell* was originally constructed with two plates of sheet lead, separated by gutta-percha strips, one sheet being laid over the other, with two gutta-percha strips between them, and two more laid on the upper sheet, as shown at *A*, Fig. 1.

They were then rolled together and clamped, as shown at *B*, a strip of lead being left attached to the corner of each sheet in cutting, by which connection could be made. The sheets thus rolled together were placed in a jar of glass or ebonite, containing a 10 per cent. solution of sulphuric acid. The jar had an ebonite cover, with binding screws to which the connecting strips were attached; also clamps for holding wires to show the heating effect of the discharge.

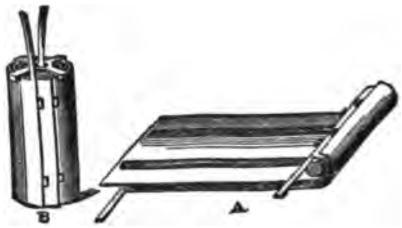


FIG. 1.—Planté's cell.

The electrical preparation of the plates was accomplished by charging them with a battery of two or more cells, one cell being insufficient to overcome the resistance from polarization. The current was continued till the oxygen evolved at the positive pole ceased to combine with the lead and was given off as gas. The cell was then disconnected from the battery, and discharged by making connection between its electrodes, and a fresh charge given in reverse order, and continued as before until gas was given off. This process was continued for several months, with intervening periods of repose, during which the cell remained charged, and the time of charging was increased from a few minutes on the first day to several hours subsequently. In like manner, the periods of repose were increased from hours to weeks and months. Three distinct periods are thus required in this process: that of charging, of repose, and of discharging, during each of which a distinct chemical reaction occurs. During the charging, peroxide of lead collects on the plate connected with the + pole, and hydrogen on the one connected with the − pole. At first only a thin film of the peroxide is formed and a small amount of hydrogen collected. The plates are then discharged, and during the discharge the peroxide, which is insoluble in sulphuric acid, is reduced to monoxide, PbO, which is immediately reduced to sulphate of lead $PbSO_4$, by the acid present in the solution, while the oxygen atom taken from the peroxide unites with the lead on the opposite plate, forming monoxide, which, in turn, is reduced to sulphate, the result being a thin film of sulphate on each plate. The plates are then charged in reverse order, and the sulphate on the plate, now connected with the + pole, is reduced by the oxygen to peroxide, while that on the opposite plate is reduced by the hydrogen to spongy lead, which adheres to the plate in a finely divided condition. As each subsequent charge, after discharge and reversal, produces the same result, each coating continues to increase in thickness, and the spongy lead affording increased facility for the formation of the peroxide, the chemical reaction proceeds more rapidly. The increased thickness of the peroxide soon interposes a strong resistance to this reaction; hence a period of repose previous to the discharge becomes necessary, and during this period, local action, as it is called, takes place. This consists in the reduction of the peroxide to sulphate from the reaction of the supporting lead plate. The metallic lead having a strong affinity for oxygen, the peroxide parts with the atom of its oxygen which unites with the lead, and the resulting monoxide is immediately reduced to sulphate by the acid. The result of the chemical reaction of the discharge having formed sulphate of lead on both plates, this sulphate lying next to the plates forms a resistance which impedes local action which takes place during the period of repose. The peroxide being limited in quantity and in close contact with the spongy lead, is rapidly reduced to sulphate, while the original peroxide coating on the other plate, from its greater thickness and the resistance of an excess of sulphate, is reduced much more slowly. These various chemical reactions result in an increased thickness of the peroxide deposit with each charge, while an increased thickness of spongy lead remains on the opposite plate after each reversal; and when the process has been continued long enough to produce a sufficient thickness of each coating for a practically serviceable cell, the alternate charging and discharging with reversal is discontinued, and the cell being ready for use, it is always thereafter charged in the same direction. When the cell is put into practical use, these chemical reactions continue the same as during the forming process, sulphate being reduced to peroxide by each charge, and peroxide to sulphate by each discharge; and the electric energy varies as to reaction, and ceases when the chemical affinities are satisfied. In the storage cell the electric energy must first be supplied from an external source, and the action, both chemical and electrical, is limited, dependent on the amount of electrical charge given.

Faure's Secondary Battery.—Camille A. Faure, a French chemist, constructed a cell based on Planté's about 1880. But he substituted mechanically prepared plates for those prepared by electricity, by coating their surfaces with a paste of red lead (minium, Pb_3O_4) and sulphuric acid, which, when subjected to electrical action, was rapidly reduced to peroxide on the one plate and spongy lead on the other. After this was applied it was coated with paper, and each plate then enveloped in felt to retain the coating on the surface and to insulate the plates from each other. They were then rolled together and placed in the acidulated water in the cell, and subjected to electric action with reversals, and in a few days the cell was ready for use. The great advantage of the Faure over the Planté cell consists

For the retention of the paste, instead of perforations, grooves or recesses have been made on the surface, or the plate is cast with projections from it so as to afford a lodgment for the active material. The *Tudor plate* (*see below*) is an instance of this type.

The construction of a mold to produce a perforation expanding inwardly is a difficult matter, and therefore the grids are cast in two halves and subsequently joined, as in the

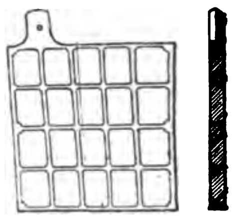


FIG. 5.—Gadot cell.

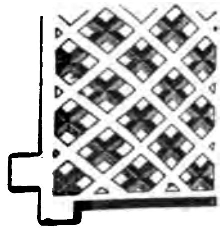


FIG. 6.—Correns cell.

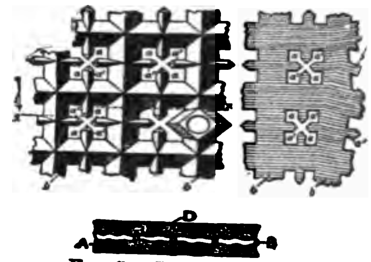


FIG. 7.—Roberts cell.

Gadot cell, Fig. 5. In the *Correns* cell, Fig. 6, much used in Germany, the grid has the form of a double lattice. In the *Roberts* cell, Fig. 7, two grids are used, pasted on the side and then united to form a plate with the paste inside.

The *Tommasi multitubular* storage battery (Fig. 8), invented by Dr. Donato Tommasi, of Paris, has each electrode formed of a perforated tube, or folded sheet, closed at one end by a small plate of insulating material, into which is screwed a rod. The rod, which serves as a support for the tube electrode, is provided with a suspension head, which also serves as a contact. Instead of cylindrical tubes, prismatic ones may be employed, as in Fig. 8, utilizing the space to better advantage. In the annular space between the tube and the contact conductor of each electrode the active material, spongy lead, or lead oxide, etc., is packed, so that the tube serves only as a support for such matter, and can be made of any substance desired, so long as it is not attacked by the acid.

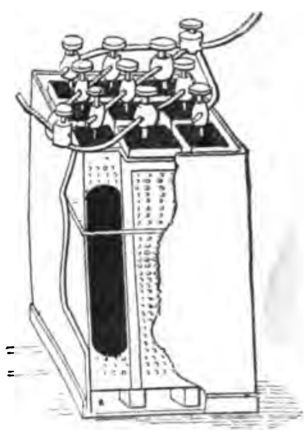


FIG. 8.—Tommasi multitubular cell.

Reynier's high voltage elastic accumulator was designed to afford a single compact structure, having the qualities of high voltage, solidity, and portability. As shown in Fig. 9, it has sixteen plates mounted in flexible pockets. These elements are placed flat one against the other, and compressed between two end plates of wood by means of rubber bands. A bridge consisting of hard wood impregnated with a waterproofing material carries the whole, which may be suspended, or rest upon its base, as desired. This arrangement gives to the active solid matter an artificial elasticity which results in large specific power and storing capacity. This continuous compression of the plates, etc., gives protection against rough handling.

The *Desmazures* storage battery (France) has its electrodes composed of amalgamated zinc plates and porous copper plates, the latter being produced by the consolidation of powdered copper under very great pressure. The zinc plates form the negative electrode and are in metallic connection with the box, which is also of zinc, while the positive plates are placed in vegetable parchment bags and suspended in the usual way. Contact with the negative plates is prevented by glass rods. The electrolyte is a mixture of chloride of sodium and a caustic solution of zinc oxide.

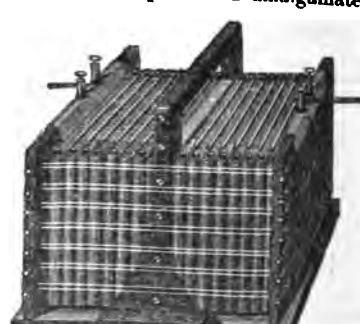


FIG. 9.—Reynier's accumulator.

The *Tamine* accumulator (Brussels) is of the Planté type, in which the liquid consists of a saturated sulphate of zinc solution, to which is added 50 per cent. sulphuric acid, 5 per cent. of sulphate of ammonia, and 5 per cent. of sulphate of mercury. In making up the cell, the ingredients are poured in in the reverse order to that given here. The addition of the sulphates of mercury and ammonia is said to prevent the formation of sulphate of lead on an open circuit. The E. M. F. of the cell is given as 2·3 volts.

The use of *Lithanode* as an active material in the anodes of storage batteries has been advocated by Desmond G. Fitz-Gerald. This substance is peroxide of lead in a dense, coherent, and highly conductive form, and is obtained by a patented process. Its chemical

plates are then short circuited. The hydrogen which is disengaged upon the positive electrode reduces the chloride of lead, and there are thus obtained buttons of spongy lead of a density between 2·5 and 3·1, while that of ordinary lead is 11·35. The buttons used in the manufacture of the positive plates are first transformed into spongy lead, then heated in the air to oxidize them, and transformed into spongy litharge. They are fixed, like the negative buttons, in a frame of antimonial lead.

In the *Tudor cell*, Fig. 13, the positive plates are first treated by Planté's process, coating them with a layer of crystalline electrolytic peroxide; the grooves are then partially filled with a paste of peroxide of lead, and pressure is applied to the ridges to expand them and partially close the mouths of the grooves.

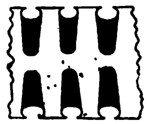


FIG. 13.—Tudor cell.

Besides the improvements in the plates, various devices have been resorted to with the view of decreasing the resistance of the lugs and securing better contact between plates of the same sign, such as making connection by tinned copper rods passed through holes in the lugs. Lead is afterwards cast around the copper so that it is screened from the action of the acid.

Dr. Paul Schoop, of Switzerland, has produced a successful gelatinous electrolyte, by adding one volume of dilute sodium silicate (water glass), density 1·18, to two volumes of dilute sulphuric acid of 1·250 density. To prevent short circuiting between the plates by the material dislodged in working, they are now either slung or rested on supports which are so placed that the formation of a layer of mud between them is prevented. See Fig. 14.

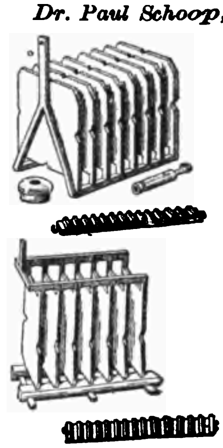


FIG. 14.—Schoop plate and holder.

Inactive material is sometimes packed between the plates to prevent short circuiting and to retain the active material. In England Barber-Starkey has tried filling in between the plates with a mixture of plaster of Paris and sawdust; Fuller used porous pots; and in the United States, in the Pumpelly battery, cellulose, or wood pulp, is used to separate the plates, which are arranged horizontally.

In the *Atlas cell*, Fig. 15, constructed by Carl Hering, the plates consist of blocks made of oxides and salts of lead.

FIG. 15.—Atlas cell.

The use of storage batteries in central station work has begun to assume large proportions. In a recent work on Continental central stations, Mr. Killingworth Hedges gives a list of stations in which batteries are a valuable adjunct. Most of the plants are small, but some of them are of quite respectable size. They run as follows: Barmen, 5,000 lamps of 16-candle power; Hanover, 30,000; Düsseldorf, 20,000; Dessau, 2,500; Rheims, 540; Berlin, 800; Bad Kösen, 600; Gevelsberg, 2,000; Bamberg, 2,700; Darmstadt, 5,800; Paris, 19,500; Gablonz, 1,500; Konigsberg, 1,600; Blankenburg, 1,000; Berlin (Hospital), 2,000; Vienna, 10,000. To this list might be added, we believe, Salzburg, Lyons, Toulon, Montpelier, Mulhausen, Stockholm, Sundsvall, Munchen-Schwabing, Varese, Susa, Bremen, Breslau, and Stettin, although few details are given with regard to these; while it appears that batteries are to be added to the Hamburg central station, which operates 12,000 lights; Wildbad-Gastein, 1,200; Elberfeld, 14,000; Arco, 2,500. It is not understood from this list that the equipment of batteries is in any instance equal to the number of lamps named; but in several cases the figures are large. Barmen, it seems, has four double sets of batteries, 68 cells each, and is now going to erect five sub-stations which will be charged during the day by the main central station. This sub-station plan has not had any trial in America, except at Cheyenne, Wyo.; Germantown, Pa., and Haverford College, Pa. At Hanover, Germany, the accumulators are placed on four floors, each battery consisting of 136 cells of 1,320 ampere hour capacity, and a discharge of 396 amperes. The Düsseldorf plant is already running three battery sub-stations; the largest has two batteries of 140 cells, each with a discharge of 483 amperes, while the other two, with an equal number of smaller cells, discharge 248 amperes. An interesting feature of the Dessau installation is the employment of gas engines as primary power. It is stated that the addition of accumulators of 1,700 ampere hour capacity to this plant increased the investment 15 per cent. and raised the output 38 per cent. The present batteries have been in use uninterruptedly for nearly two years without attention, so it is asserted, and more than once have been called upon for an output 20 to 25 per cent. above the normal.

As to the work done in Paris, France, with storage batteries in central stations, Mr. Stanley C. C. Currie says: "The principle adopted is that of casting chloride of lead combined with a small proportion of chloride of zinc in tablets. These tablets are then placed in a special mold, and ordinary lead cast around them, thus forming a uniform plate. The plates weigh about 20 kilos (44 lbs.) each. The cells contain from 15 to 25 of these plates, making the average total weight of plates per cell about half a ton. The efficiency has averaged from 72 to 85 per cent."

The following table gives the data of the tests of different cells:

[For more extended descriptions of storage batteries and the principles involved in their construction and method of operation, the reader is referred to the following works: *The Chemistry of the Secondary Batteries of Planté and Faure*, by Gladstone and Tribe: *The Storage of Electrical Energy*, by G. Planté; *The Electric Accumulator*, by E. Reynier; *Complete Handbook on the Management of Accumulators*, by Sir D. Salomons; *Accumulateurs Electriques*, by René Tamine; *Les Voltamètres-Régulateurs*, by E. Reynier; *Die Accumulatoren fuer Elektricitaet*, by E. Hoppe; *Storage Battery*, by J. T. Niblett. Also the exhaustive researches of Ayrton (*Proc. London Inst. Elec. Eng.*, 1890); Richardson (*Journ. Soc. Arts*, London, December 4, 1891). Consult also the electrical journals.]

Stoves, Air Heating: see Air Compressors.

STOVES, HOT-BLAST. During the past ten years a marked improvement has been made in blast-furnace practice in the universal introduction in large furnaces of fire-brick stoves instead of the iron-pipe stoves formerly used. The improvements have consisted in making them much taller, and in providing better facilities for cleaning them and better

FIG. 1. Fire-brick stoves. FIG. 2.

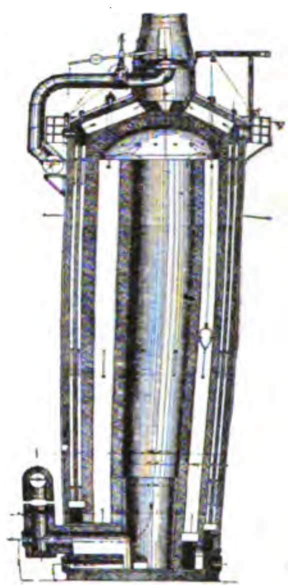


FIG. 3.—Hot-blast stove.

valves for distributing the gas and air. It is now generally customary to provide a short chimney on top of each stove, instead of one tall chimney for a series of stoves, connected to them by underground flues.

The Gordon-Whitwell-Cowper Fire-brick Stove, built by the Philadelphia Engineering Works, is shown in Figs. 1 and 2.

The arch spanning the combustion chamber and covering the first down pass has a span of just half the diameter of the stove, under which there is ample play for the gases, giving every opportunity for a utilization of all the checker-work of the down pass. On top of this short-span arch are built the flues to convey the gases from the top of the chimney pass to the chimney and the bottom brickwork of the chimney proper. To reach the chimney the gases pass down to the bottom and up the chimney pass. The gases from the combustion chamber enter the down pass, and having passed through it, enter through large arches into the chamber beneath the two symmetrical passes, forming a chimney pass, and rising through them, give off their remaining heat to the checker work, and are received on top into chambers above the checker-work. From each of these segmental passes there are two flues or passages, making four in all, leading to the base of the chimney. The checker-work in all cases has 4½-in. walls and 9-in. openings, which are either square or circular.

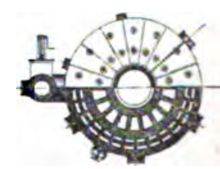


FIG. 4.—Hot-blast stove.

Massick & Crooke's Hot-blast Stove is shown in Figs. 3 and 4. This is an English form of stove recently introduced in the United States by McClure & Amsler, of Pittsburgh. The shell is the ordinary wrought-iron cylinder, with a conical-shaped top. Each stove has its own draft stack. In the center is a large combustion chamber, into which the gases are admitted at the bottom, thence passing upward and down through a series of large segmental-shaped flues, and upward through smaller flues to the escape at the top. The mushroom chimney valve, down when the gases are burning, and up when the blast is on.

The Bennett Stump Puller, shown in Fig. 1, requires no horse. It hangs from a tripod, the feet of which are carried on runners for convenient locomotion. The whole operating parts depend from a swivel supported by a clevis. They consist of a large ratchet wheel having a small sheave fastened at one side, upon which is to be wound the lifting chain by the consecutive upward and downward movement of the hand lever, which rotates the ratchet wheel by means of a dog, while another dog prevents the ratchet wheel from reverting. The lever can be shifted on a notched fulcrum so as to change the leverage for greater or less strains ; thus the ratchet wheel may be moved through an arc covered by several of its teeth, when the work is light, for each vibration of the hand lever, greatly expediting the work. A lower pulley is used in very heavy work, doubling the power at the sacrifice of speed. The lifted stump is lowered to the ground steadily by the use of the brake, *M*. The hook, *O*, is hooked over the end of the short pawl, *P*. The link, *G*, is hooked over the end of the brake, *M*. The hand lever is then depressed, permitting the pawl, *H*, to disengage by the action of the spring in the hook, *O*. The weight of the stump then causes it to run down according as the hand lever is eased up. A spring, *T*, serves to restrain the link, *G*, from flying away from the large ratchet wheel while the operator is plying the hand lever.

Harvey's Stump Puller, shown in Fig. 2, pulls trees as well as stumps, as it may be placed at a distance from the work, and the stump or tree pulled in any direction by introducing an intermediary block. In the drawing, one of the corner posts is omitted, to expose the construction. It consists of an upright loose drum and ratchet, through which passes a shaft, round within the drum, and square at the upper portion, to carry with it a clutch with teeth for engaging and rotating the drum. The shaft has top and bottom bearings, and projects at top through an iron cap, which surmounts the timber framework of the machine, and is there fitted with a sweep seat for the sweep lever, to which one horse is attached to do the work. In practice, the machine is set in the ground firmly, and used without change of position to clear stumps from the surrounding land to the extent of as much as two acres of area without removal. Should any stump stand where the cable used in connection with the winding drum interferes with either corner post of the machine, the horse is made to travel the other way, winding the cable onto the opposite side of the drum, thus allowing the cable to swing clear. The safety pawl is held to the check ratchet by a spring, and is so made that it holds in either direction in which it may be set. The power of this machine can be indefinitely increased by the use of block and tackle attached to a second stump as a purchase, and it is therefore specially useful in regions of heavy timber, where the stumps are large. It is known as the "California" stump puller.

Sugar Machinery : see Evaporators.

SUPERHEATER, STEAM. *The Bulkley Steam Superheater* is shown in Figs. 1 and 2. It consists of a group of cast-iron pipes filled with iron wire coils closely packed, the surfaces

FIG. 1.—The Bulkley superheater.

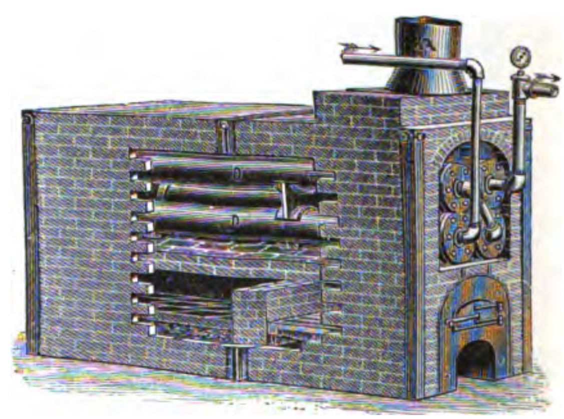


FIG. 2.—The Bulkley superheater.

of which act as additional heating surface to that of the cast-iron pipe to transmit heat to the steam which is passed through the pipes. The group of pipes may be set either in the rear of the steam boiler furnace, or in a special furnace, as shown in Fig. 2. The latter plan is preferable where a high degree of heat is desired. The steam may be superheated in this apparatus to 1,000° F. Steam of from 500° to 700° temperature is frequently used in chemical, oil, gas works, etc. The temperature is ascertained by a pyrometer set in the outlet steam pipe, as shown in the cut.

SWAGING MACHINES. Figs. 1, 2, and 3 represent the Dayton swaging machine, as used by the Excelsior Needle Co., at Torrington, Conn., for the swaging of needle blanks. It contains a revolving shaft having across its end a mortise or groove, and a

wire, rod, shaft, or bar that is operated on, and its grooved portion is of enlarged diameter. If the shaft is revolved by the pulley, the article to be acted upon will only require to be fed in gradually, and be free to be revolved by the action of the dies as they move slightly while grasping the work.

In Fig. 2, *D D* are screws passing through a plate secured to the face of the shaft, *A*. The points as shown project into enlarged holes in the blocks, *C C'*, and limit the extent of outward motion of these. An outside ring, *F*, is screwed to the casting, *B*, making the machine ready for work. Where two dies are used there must be an even number of rollers, so that they act at opposite sides of the shell. Three-die machines built on the same principle require 6, 9, or 12 rollers, the dies being placed at angles of 120°. Near the bottom of Fig. 2 is shown a specimen of work done in the machine—a drawn-down sewing-machine needle blank. Comparison of the lower with the upper of the two engravings, which latter represents the blank originally, shows that the whole amount of metal in the elongated portion corresponds to that embraced between the lines, *a b*. The diameters of the blank originally and of the drawn-down portion are 0·081 and 0·012 in. respectively. At the works of the Excelsior Needle Co. a number of the machines are engaged exclusively in the swaging of sewing-machine needle blanks, though obviously they are applicable to a variety of other work. Machines of larger size are used for pointing rods preparatory to drawing into wire, and also for working in iron and steel in various lines of manufacture.

SWITCHES AND SIGNALS, RAILROAD. ROAD SIGNALS.—The practice has become quite pronounced in favor of the use of semaphore signals for the purpose of protecting the movements of trains, as the semaphore most easily lends itself, through the simplicity of its form, to all of the many requirements of traffic. The most prominent forms of the semaphore are the home, distant, and dwarf signals, all of them modifications of the same idea.

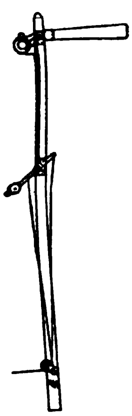


FIG. 1.—Home signal.

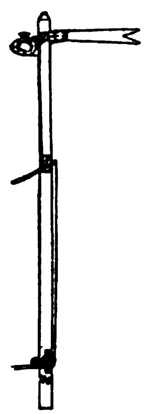


FIG. 2.—Distant signal.

Home Signal.—The home signal, Fig. 1, consists of a blade about 5 ft. long, with a square end, mounted on a post about 25 ft. above the rail level. It is usually painted red on the side toward approaching trains which it governs, and white on the other side. On double track, right-hand running, the blade points to the right; on double track, left-hand running, the blade points to the left in some cases, and in others to the right. When in a horizontal position, or showing a red light at night, it indicates danger or stop. When inclined at an angle of from 60° to 90°, or showing a white light at night, it indicates safety, or go ahead. It is only used in connection with movements in the direction of the traffic on the main track, or to control movements from the main track to facing point diverging tracks, or facing point cross-overs.

Distant Signal.—The distant signal, Fig. 2, consists of a blade about 5 ft. long, with a forked end, mounted on a post about 25 ft. above the rail level. It is usually painted green on the side toward approaching trains which it governs, and white on the other side. Its location with regard to the tracks and the direction in which it points is the same as that of the home signal. When inclined at an angle of from 60° to 90°, or showing a white light at night, it indicates that the home signal in connection with which it works is in the safety position, and that trains may proceed with speed. When in a horizontal position, or showing a green light at night, it indicates that the home signal is probably at danger, and that trains must proceed with sufficient caution to enable them to stop before reaching the home signal, if necessary. It is used always in connection with a home signal, and serves only to show the position of the home signal, which controls movements over the fastest and most important route.

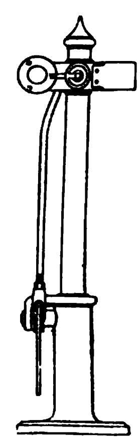


FIG. 3.—Dwarf signal.

Dwarf Signal.—The dwarf signal, Fig. 3, consists of a blade about 12 in. long, with a square end, mounted on a post about 2 ft. above rail level. The painting of the blade, its relative positions of danger and safety, and the position with regard to the tracks are the same as described in the case of the home signal. It is, in fact, a diminutive home signal, but is used only to control movements in a reverse direction on double track, and for movements from side track to main track, and from side track to side track.

The great advantage of the semaphore form is, that identically the same signal can be used for both block and interlocking purposes.

BLOCK SIGNALS.—The question of blocking a piece of track has resolved itself into the two principles of time and positive block signaling. The time signals are most prominently represented by the Fontaine signal, which consists of a track instrument controlling a dash-pot and the operation of some clock-work which may be set to run any desired number of minutes after the passage of a train. The two great objections to this method are: First, that it is not at all certain that a train has passed out of the block simply because the hand indicates that it has been gone a certain number of minutes; and, second, that the indications of the signal are visible at only a short distance.

and the Westinghouse pneumatic signal, both owned and manufactured by the Union Switch and Signal Co, and the Hall signal, owned and manufactured by the Hall Signal Co.

The Hall Signal is described in *Appletons' Cyclopædia of Applied Mechanics*, but certain changes have been made which permit the entrance of a second train into an already occupied section, while still maintaining a danger signal in its rear. This is accomplished by the intervention of a combination of relays and track instruments, whereby the second train on passing the clearing track instrument for the section which it has just left cuts out the clearing track instrument for the section which it occupies, so that the first train cannot clear the signal for that section.

The Union Electric Signal and the *Westinghouse Pneumatic Signal* both depend funda-

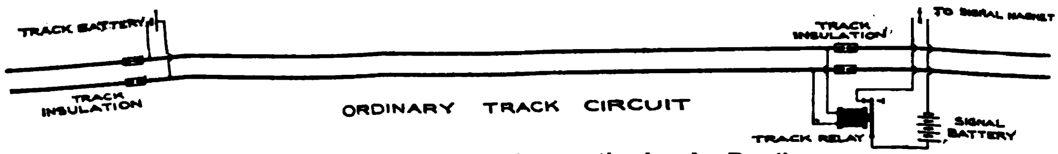


FIG. 5.—Electric and pneumatic signal. Details.

mentally on the use of the track circuit, which is illustrated in Fig. 5. The track circuit is a section of both rails of a piece of single track in which the ends of adjacent rails are connected by a piece of wire (see Fig. 6), and the ends of the rails in one section are insu-

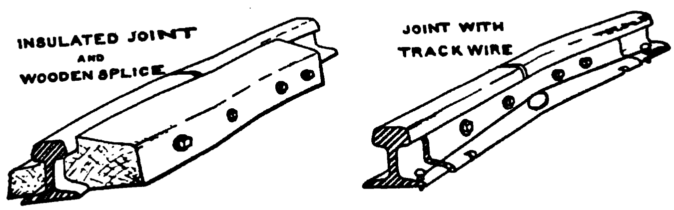


FIG. 6.—Track circuit.

lated from the ends of the rails in the section adjacent to it. In each section the ends of the two lines of rails of one end are connected together through a battery, while the two lines of rails at the other end of the section are connected by a relay which controls the signal circuit. The presence of a train on any portion of a block, or the opening of a switch, or the breaking of a rail will interrupt the track circuit, and thus set the signal to danger, which is operated by it. So far this method is common to both systems.

The Union Electric Signal consists of a combination of clock-work and electric mechanism which is directly controlled by the track relay mentioned in the description of the track circuit. The motive power consists of a heavy weight. In the past this signal has been built usually as a disk signal, with a continuous motion to the right. The demand for semaphores has, however, caused a change to be made in its form which has entailed certain alterations in the method of transmitting the motion from the operating mechanism to the vertical shaft on which the semaphores are mounted. This motion is now reciprocal instead of continuous. The present external appearance of the signal is shown in Fig. 7, the signal presenting alternately the edge and surface of its two blades to the view of an approaching train. The blades, which are of the ordinary home or distant signal form, as the case may be, are placed at right angles to each other on a revolving shaft, which moves through an arc of 90° in one operation, and returns to its original position in the next. The mechanism operating and controlling this signal is outlined in Fig. 8. The rotary movement of the shaft, *S*, obtained by the weight passing over a sprocket wheel secured to it, is transmitted to one of a higher speed in a second horizontal shaft immediately above it, to which the cross, *C*, is secured by means of a large gear wheel and a pinion. The motion of this shaft, besides revolving the cross, *C*, causes a vertical shaft projecting through the top of the machine to revolve at the same rate of speed through the engagement of two beveled

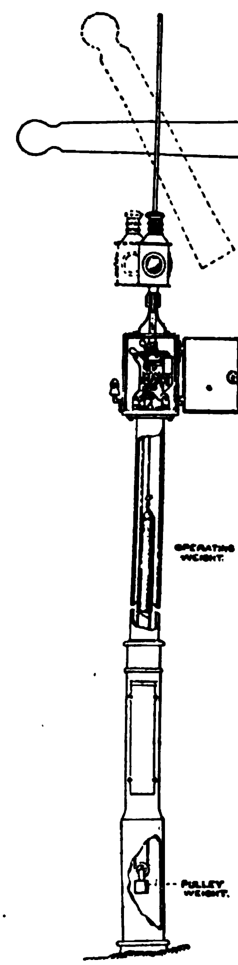


FIG. 7.—Union electric signal.

rubber pin in the nut approaches the point of contact between two springs through which the current controlling the magnet of the signal is made to pass. and causes their separation just before the operating weight has reached the bottom of the post, thus cutting off all current from the magnet, and thereby causing it to stop in the danger position before the operating power is exhausted. A considerable momentum is gained by the revolution of the semaphore arm, which would cause heavy strains were it not taken care of. This is accomplished by separating the external shaft and semaphores entirely from the rest of the mechanism. Secured to the base of the external shaft and to the top of the internal shaft are friction clutches which correspond and fit into each other. When the shaft revolves the clutch permits a revolution a little greater than the normal one, but as the sides of the clutch are inclined the shaft immediately drops back into the proper position.

The Westinghouse Pneumatic Signal system, as before stated, is controlled by the location of the trains which are passing over the road. It is illustrated in Fig. 9, and, as its name implies, the signals are brought to the clear position by the presence of compressed air in the cylinder. The magnet which controls the admission of air into the cylinder is directly controlled by the track relay, which is located on the signal post and is mentioned in the description of the rail circuit. A clear section permits the current from the track battery (see Fig. 5) to pass through the track relay, completing the circuit through the signal battery and energizing the magnet. This unseats the valve which is connected directly with the armature of the magnet, and permits the compressed air from the main pipe line to pass into the cylinder, thus driving out the piston, and lowering the signal to which it is directly connected. In actual practice the distant signal for a succeeding block is located on the same post with the home signal for the block immediately in advance. This arrangement is for the purpose of indicating to trains a considerable distance in advance as to what condition the track is in, and permits of a much higher rate of speed than if trains received their signals only at the beginning of the block on which they wished to enter. The distant signal, however, may be located any desired distance from its home signal. In connection with the pneumatic block signaling system, a pneumatic lock is located at each switch connecting with the main track, which prevents the opening of a switch after a train has entered upon that section, and which, when the switch is once opened, sets all the signals controlling that section to danger. The compressed air which operates this system is derived from air-compressors located at any convenient point near the right of way, not to exceed 20 miles apart. As will be explained further on, this air can be and is used for operating the switches at interlocking points.

INTERLOCKING.—*Mechanical Interlocking.*—The method of interlocking known as the Saxby & Farmer, and described in the previous issue, has been abandoned, and the Stevens type has now entirely taken its place. The Stevens locking has two forms. In the original form, which is illustrated in Fig. 10, the tappet, which is directly connected with the lever, operates the locking bars, which run parallel with the greatest length of the machine, or, in other words, at right angles to the motion of the levers. This is objectionable from the fact that in large machines the locking bars become very long and heavy, and the method of driving them by the tappet creates a large amount of friction and results in considerable lost motion in time. In the latest form, see Fig. 11, the Saxby & Farmer arrangement is retained, the flop of the Saxby & Farmer machine being replaced by a simple shaft connected with the link by a universal joint. A movement of the latch handle of the lever rotates this shaft and transfers the movement to the locking bar, which slides in a direction perpendicular to the plane of the movement of the lever. By this arrangement the locking is made

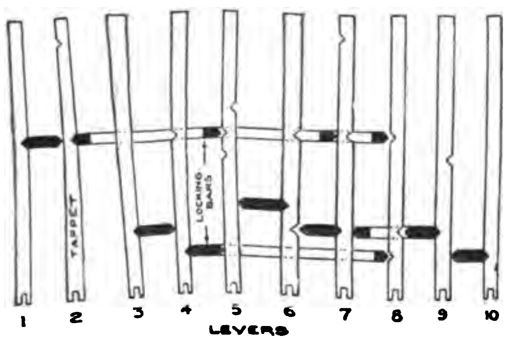


FIG. 10.—Interlocking system.

FIG. 11.—Stevens interlocking system.

extremely compact, and is located in plain view above the floor of the cabin, easy of access for cleaning and repairs.

the current is taken directly from a storage battery. *The signal movements* used in the pneumatic interlocking are the same as those used in the pneumatic block signaling, which have already been described. *The Pneumatic Switch Valve and Cylinder* is illustrated in horizontal section in Fig. 14, and in external appearance, together with the switch and lock movement, in Fig. 15. The outside magnets, *A* and *C*, control alternately, depending on the position of the lever in the tower, the admission of air into the valve cylinder. The central magnet, *B*, controls the valve lock. By moving a switch lever in the tower, the following operation takes place: The magnet, *B*, is first charged (it is so shown in the drawing), which admits air into the lock cylinder and releases the slide valve, leaving it free to move as soon as the pressure shall be applied to it from cylinder *1*. Magnet *C* is then charged, and magnet *A* is discharged, permitting the entrance of air into cylinder *1* and opening the exhaust port of cylinder *2*. This forces over the slide valve to its other position, allowing the entrance of pressure to the right-hand side of the main cylinder, and connecting the left-hand side of the main cylinder with the atmosphere. The last movement of the lever in the tower cuts the current out of the magnet *B*, thereby locking up the slide valve in its new position.

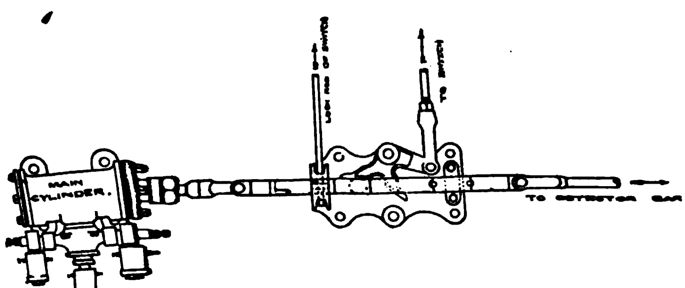


FIG. 15.—Valve and cylinder with lock.

The switch movement shown in Fig. 15 is the same as that described under the head of mechanical interlocking. A pin in the slide bar transmits the power to the wide jaw to which the switch is connected. The detector bar and lock, however, are connected directly to the slide bar, and move during its whole stroke, while the switch moves only during the middle part of the stroke.

TABULATING MACHINE. *The Hollerith Electric Tabulating System* may be considered the mechanical equivalent of the method of compiling statistics by writing on slips or cards the various items regarding the units to be compiled, one such written card representing a single unit, as, for example, in the case of a census, a person; and then sorting and re-sorting these written cards according to the characteristics of the individuals, and counting the number of cards finally in each group. In this mechanical equivalent the characteristics or items of the individuals are transcribed to the cards by punching holes in different positions instead of writing, and then counting and sorting these punched cards in the electrical tabulating machines. The work, therefore, naturally divides itself into—first, the transcription of the record; and, secondly, the tabulation of the data. As the system has been mostly used for the compilation of the eleventh census of the United States, the following description will be based upon such work:

In order to transcribe the particulars as to each individual from the original schedules, a keyboard punch is used about the size of a type-writer tray, having in front a perforated punch-board of celluloid. Over this keyboard swings freely an index finger, whose movement, after the manner of a pantagraph, is repeated at the rear by a punch. The movement of the punch is limited between two guides, upon which are placed thin manilla cards 6⅝ in. long by 3¼ in. high, with the lower corner slightly clipped. The keyboard has 12 rows of 20 holes, and each hole has its distinctive lettering or number that corresponds to the inquiry and answer respecting every person. Hence, when the index finger is pressed down into any one of these holes, the punch at the back stamps out a hole in the manilla card. At first glance, perhaps, the keyboard looks complicated, but it is scientifically grouped and is very readily learned. For such inquiries as are answered by one of a very few possible classes—sex, for example, which recognizes only two parties in the State—the answer is simply "male" or "female," or "M" and "F." So, too, in regard to conjugal relationships, where the answer would be either single, married, widowed, or divorced, and one punch suffices for each of these conditions.

To assist the clerks in memorizing the keyboard for punching, classification lists are used. That the work of punching became as easy as any other task requiring ordinary intelligence is shown in the fact that during the tabulating of the eleventh census, the estimated average of 500 cards per day per clerk resolved itself very soon into an actual average of 700. An expert puncher, working from 9 A.M. to 4 P.M., has done 2,521 cards, each card having on an average about 15 holes in it that relate specifically to the individual whose life history is thus condensed.

After the cards leave the punching clerks, they are kept in their Enumeration Districts, and they have now to be further punched to show the exact locality they belong to—*i.e.*, the civil division of which the enumeration district formed a part. For this purpose the space of about 1 in. across the left-hand end of the card was left blank, no portion of it being punched on the keyboard punch. This space is further divided by imaginary lines into 48 squares, in the combinations of which every enumeration district can be recorded [in the U. S. census over 40,000 such districts were thus recorded], and it is perfo-

Fig. 5. The front of each counter is 3 in. square, and, as now made, consists of paper ingeniously coated with celluloid, ensuring a smooth, bright, clean face. Each dial is divided into 100 parts, and two hands travel over the face, one counting units and the other hundreds. The train of clockwork is operated electrically by means of the electro-magnet, whose armature, as it moves each time the circuit is closed, carries the unit hand forward one division, while every complete revolution actuates a carrying device, which, in turn, causes the hundred hand to count. In this way each dial will register up to 10,000. A noteworthy feature of these ingenious little dials is that they can quickly be reset at zero, while they are also removable and interchangeable. The electrical connections are made simply by slipping them into frames and clips.

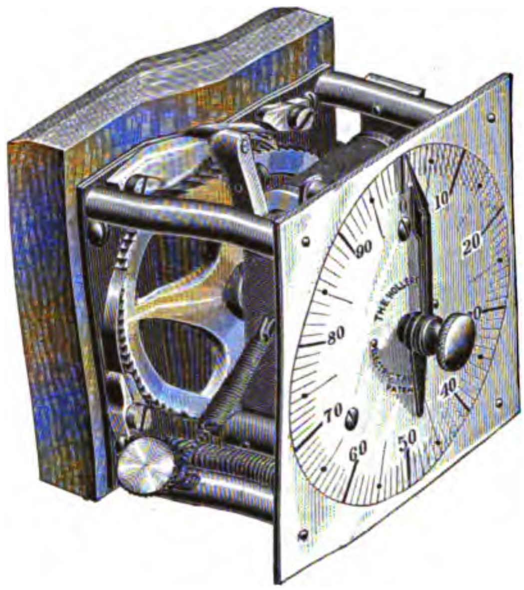


FIG. 4.—Counter.

The third element in the system is the sorting box, shown in Fig. 6 in perspective. The box is divided into numerous compartments, each of which is kept closed by a lid. The lid is held closed against the tension of a spring by a catch at the free end of the armature of a suitable magnet. If the circuit through this magnet is closed, by the press on the machine, the armature is pulled down, releasing the trigger of the lid, which is at once thrown up by the spring, and remains open until flipped back by a slight touch of the operator's hand. The connections with the machine are made by means of the short table seen at the left of the sorting box. In the cut the wires are shown attached to binding posts on a small board, but a minor change has been made by which the board is pushed in between contact clips in the machine, thus saving valuable time by obviating the necessity of screwing and unscrewing so many binding posts whenever it is desired to remove the box for any reason.

If, now, it is desired to know in a given enumeration district, or all of them, the number

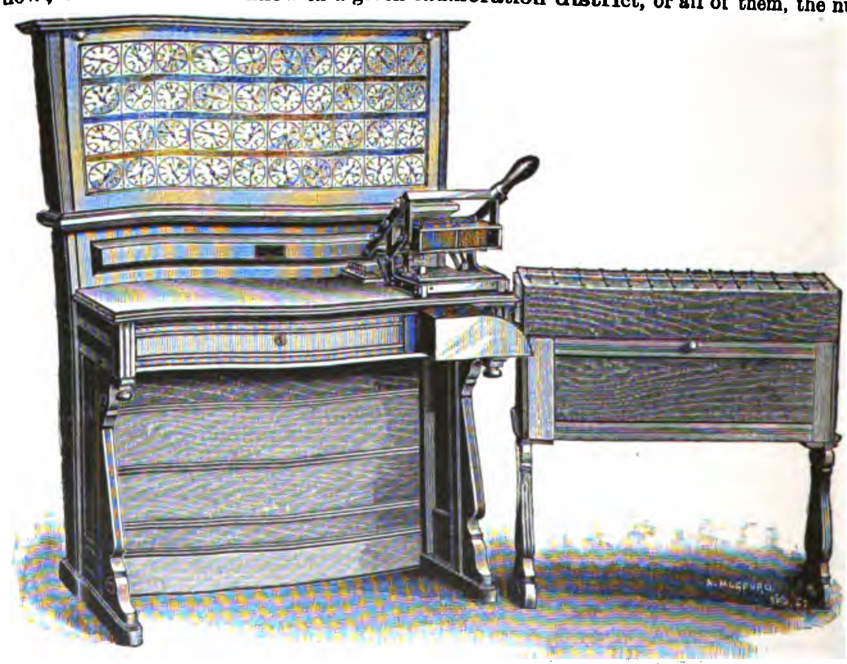


FIG. 5.—The Hollerith electric tabulating machine.

of males and females, white and colored, single, married, widowed, etc., the binding posts of the switchboard corresponding with this data are connected with the binding posts of the

bination can be effected in this manner. An elementary manner of building up the combination is shown in diagram in Fig. 7. It is simply a question of arranging the counting dials and the relays, or, if desired, the sorting boxes can be treated in the same way. When the machine is once connected up, the combination sought yields its results just as readily as though it were a single item.

There is another side of this method. We have just indicated refinement in detail of one kind, but the machine lends itself to analytical work not less than synthetical. In statistical investigation the analysis naturally becomes finer as the area enlarges, and here the sorting box is of great service. As has already been stated the cards are primarily massed in enumeration districts For such small areas, the information required groups the population under comparatively few heads. In practice it is found that such classification can generally be counted on the 40 dials that the machine embraces normally as a full equipment; and the arrangement is made accordingly. But while counting this classification, the cards can also be assorted into groups that will form the basis of the analysis for the next larger group of territorial areas; so that if the cards are divided into twenty groups, we shall have at the next handling of the cards, a classification of 20 x 40, or 800 heads. If, at the next step, we subdivide each one of these twenty groups into twenty more, the third handling of the cards will give us 20 x 20 x 40, or no fewer than 16,000 heads. Thus a very few manipulations will give an extraordinarily fine degree of analysis, and the compilation will have a value from its minuteness that could be reached in no other way.

Added to the ability to secure special details, finer analysis, and the economy in time and labor, we have the greater accuracy. The machine automatically throws out any card that is wrong. Suppose, for instance, that age or sex has not been punched. Where there should be a hole for the plunger-pin to go through, closing the circuit, the card is intact. The circuit is open, and the monitor bell just to the left of the press, refuses to give its cheery signal of correctness. It is then a very easy matter to refer back to the schedule stowed away in the old church across the street, and fill up the deficiency by the paradoxical process of making a hole. Suppose it was desired to connect up the machine so that only cards for New York should be counted. A missorted card belonging to Chicago would at once be rejected. The gang punches of the two cities not agreeing, the wrong cards would leave the circuit open.

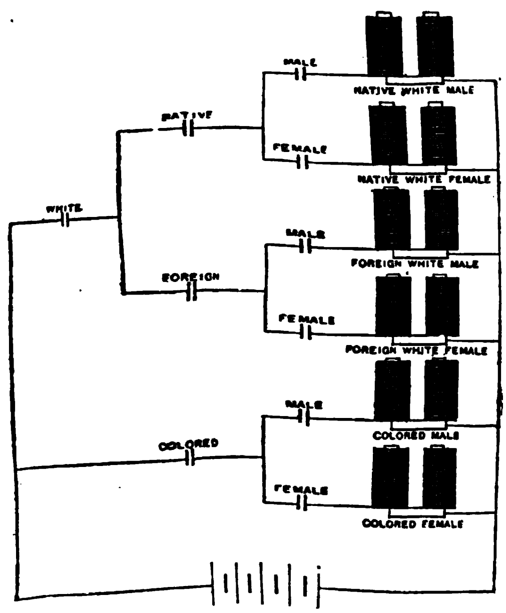


FIG. 7.—Method of arrangement for combination counting.

That all of a batch of cards purporting to represent some one class are properly assorted, is simply ascertainable by passing a wire or needle through the holes representing the given class. This could evidently not be done with written cards, and locating a misplaced written card among a million other cards is practically impossible. The probabilities of error in reality narrow themselves down to the punching, and even then the only errors that escape detection are those in which the information given, while it may not furnish the exact fact, is still consistent with the other facts punched. Even these could be eliminated by comparison or check of every card. It is to be borne in mind, too, that a card wrongly punched involves only the possible miscounting of a single unit, whereas in all previous methods the counting up on sheets has involved possible miscount at each footing up of a column.

In the compilation of census statistics, such as those of population, mortality, etc., or the bulk of the work to which this apparatus has heretofore been applied, the person forms that unit, so that each card represents simply that unit. But the census includes agricultural, manufacturing and similar statistics, and it is evident that in the figures of agriculture or manufacture, while a card might represent a farm or a factory unit, the *value* of that unit might vary greatly. Thus it might be a farm of 100 acres or of 500, and we would thus have to record *amounts*. This is done by a specially constructed machine containing a cylinder around whose circumference studs are set; spring contact points connected to the mercury cups of the press; a motor for revolving the cylinder, and a device for starting and stopping the motor so that the cylinder will make one revolution for each card. The operation can be readily understood. A card being put in the press, the circuit is closed through a given counter to the battery, to the cylinder of the integrating device, from one of the nine contact strips of the integrator through the corresponding mercury cup uncovered by the punched hole of the card through the plunger of the pin box corresponding to that hole, and back to the counter. At the same time, when the handle is brought down, another circuit is closed

vibrate the siphon, with the object of preventing friction at the marking point of Sir William Thomson's siphon recorder, has always been the one defect in this otherwise most perfect and beautiful instrument; for, as is well-known, in damp weather, static electricity is difficult to produce and well-nigh impossible to control.

The invention of Mr. C. Cuttriss, Fig. 4, obviates all this trouble by the use of magnetism,

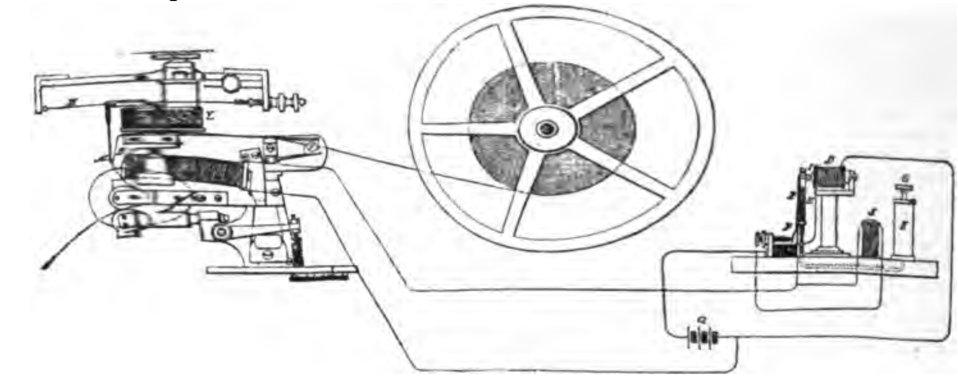


Fig. 4.—Cuttriss siphon vibrator for ocean cables.

and the instrument works just as perfectly be the weather damp or dry. The siphon, *M*, is made slightly thicker toward the point; this is caused by a small particle of iron wire, No. 30 or 32, about $\frac{1}{16}$ or $\frac{3}{32}$ of an inch in length, fastened to it by a little shellac varnish. The magnetic recording table, *B*, opposite the point of the siphon, over which the paper slip passes, is made partly of iron, and to the back of it is the electro-magnet, *C*. The principal part of the invention is the adjustable vibrator at the right of the illustration. The glass tube, *E*, and armature, *I*, which are supported by the steel rod, *P*, are vibrated by an electro-magnet, *D*. Continuous vibration is maintained by means of the battery, *Q*, and the contact points, *F*. The upright mercury reservoir, *K*, has a regulating screw, *G*, the lower end of which is made to act as a plunger; a small india-rubber tube connects the mercury reservoir with the glass tube, *E*, so that by raising or depressing the plunger the mercury can be forced and maintained at any required height in the glass tube, and by this means its rate of vibration can be changed as may be required. When a siphon is attached to the strained wire, *X*, and it has become filled with ink from the ink reservoir, *Y*, the plunger is manipulated until the siphon attains its maximum arc of vibration. A perfectly steady dotted line is then obtained, and will continue without any other regulation so long as it remains filled with ink.

Transmission of Morse Characters on Submarine Cables.—Mr. Patrick B. Delany has perfected an invention by which long cables may be operated by any Morse operator, and by which the received characters are not only greatly improved, but the rapidity with which they may be transmitted greatly increased. When the key is pressed down, a current of one polarity is sent. If it is immediately lifted up, a current of opposite polarity is sent, lasting for the short time between the downward and upward movement, forming a dot. If the key be held down, a dash is formed, not by the passage of a long impulse, but because the opposite polarity which terminates each signal is deferred until the key is lifted up. One current is the beginning of all signals, the other is the ending; the time between the beginning and the end determines whether the signal is a dot or a dash. There are no dashes sent into the line, but all currents are of equal duration and alternating in polarity.

On the 9th and 16th of September, 1888, Mr. Delany's transmitter was tried over the Anglo-American cable from Duxbury, Mass., to St. Pierre, and the results obtained more than confirmed expectations. The cable is 878 miles in length, 8,300 ohms resistance, and 256 microfarads capacity. We reproduce in Fig. 5 the record received at St. Pierre at different rates of speed, varying from 13 to 34 words per minute, with accurate timing and five letters to a word. During the same test, Mr. Delany transmitted twenty words per minute, every letter of which was received perfectly at St. Pierre, on a Morse sounder. This is by far the longest cable circuit ever worked by sound, and the speed of twenty words per minute on such a circuit is a great stride in cable telegraphy. Mr. Delany believes that he can increase the speed to thirty words per minute, and has strong hopes of working the main Atlantic cables by sound at no very distant day.

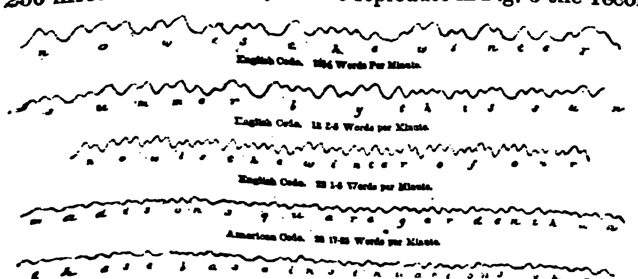


Fig. 5.—Cable transmission.

means its speed may be regulated and controlled; it is shown in the middle of the diagram. The lamps, *11*, are in the armature circuit in multiple arc, and by turning them on or off, the speed of the pole changer may be varied, the field remaining of uniform intensity excited by the battery, *10*. This pole changer sends rapidly reversed currents continuously to line, and maintains the polarized relays at X and Y in constant and rapid vibration. They necessarily beat in synchronism, and are reversed by every half revolution of the controlling motor. These alternations set the pace of as many machines as it may be desired to place in circuit. Very little current is used for this purpose, the battery line on a one hundred mile circuit having only about 30 volts potential. The current is necessarily very weak, and the vibration of the polarized relays is delicate but constant.

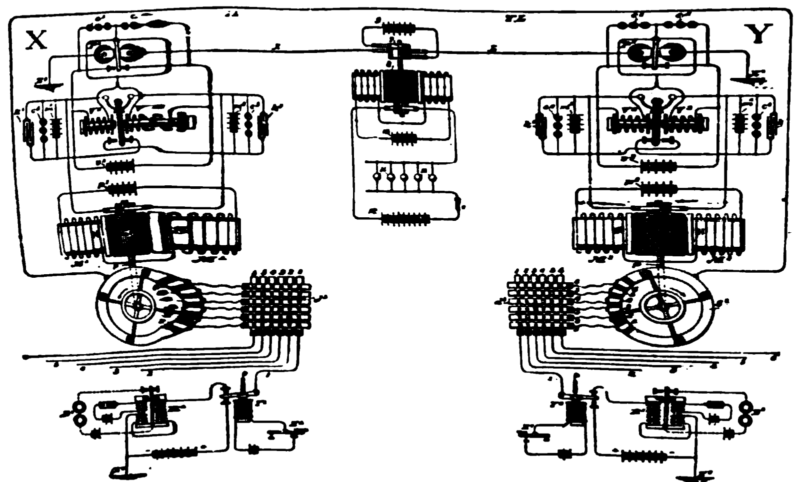


FIG. 6.—Patten synchronous multiplex telegraph.

The armatures of these polarized relays drive a powerful vibrator in the same way that a relay actuates a sounder, the vibrator being placed upon a local circuit of low tension, v^1 v^2, and this is given sufficient strength and a suitable form to both rapidly reverse and convey the heavy currents of the motor armatures. These vibrators are shown at v^2 in the diagram, which is sufficiently clear to explain their operative parts. The polarized relay, as it vibrates to and fro, places alternately one side and the other of the vibrator in circuit, and its armature is rapidly and strongly pulled first against one contact point and then the other.

It being now understood how the regulator at some intermediate station keeps the polarized relays in unison movement, and they in turn maintain the local vibrators in corresponding unison movement, it will be explained how this system of devices maintains the motors at distant stations in synchronous rotation. The motors are shown at X and Y by diagram circuits, M^1 and M^2; the fields, $N\,S$, are constantly and separately excited by the batteries, P^1 and P^2, while the armatures receive their current alternately in opposite direction from the batteries, m^1 m^3, at X, and m^2 m^4 at Y, as the vibrator armatures move to and fro.

The motor armatures are of peculiar construction, and will continue in rotation when supplied with a current of rapidly reversed direction, the connections being such that a constant polarity of the armature is maintained with reversed currents, provided the armature turns through a certain arc of the circumference at each reversal of the current. As the system is now used, they are so connected that they move one-fourth of the revolution at each reversal of current. The synchronism is thus corrected automatically four times in each revolution; it may be made eight or twelve, or more, if desired. The spindles of the armature have secured to them revolving trailer arms carrying brushes which sweep over the segmental distributors, s^1 and s^2. They are shown flat in the diagram, for clearness, but are evidently at right angles to the spindles, which in practice are vertical, as shown in Fig. 7, which represents the machine in perspective.


FIG. 7.—Distributor motor.

The telegraph line extends also from earth, E^1 at X, to E^2 at Y, one set of instruments being shown in detail at each end. The circuit may be traced as follows, the operator at X being supposed to be sending, and the operator at Y receiving: From earth, E^1, through the line battery positive to line, transmitter contact, t^1, switch, d^1, segment No. 1 of the distributor, and through the trailing brush to the large segment of the distributor, to which the line is connected at X;

core, and the tendency is to momentarily throw off the armature; but at the same instant of the reversal of polarity an induced current is set up in the bobbin, B, which is in opposite direction to the primary, and which, in circulating through C, tends always to magnetize the core, H, oppositely to that of the main core, and hence, with a corresponding influence upon the small armature, K. The result of this is, evidently, that with two opposite influences acting upon the lever, it will remain stationary and insensible to the effects of the reverse currents.

We come now to the third and last method employed in transmission, which consists in sending a rapidly vibrating current over the line, which is made to set a telephonic diaphragm in vibration.

The source of the vibratory current is the small dynamo shown at A. From the arrangement of circuits, it will be seen that the commutator, B, cuts the line coils of the vibratory magneto, that is, the outer ring of magnets, out of circuit, except at the instant of passage of the poles, and thus reduces the resistance of the circuit from 160 to 5 ohms, which changes evidently occur in continuous rapid succession, sending a vibratory current over the line. These currents charge the condenser, O', at the distant station, which tends to increase their abruptness, and thence pass into the vibratory receiver or relay $3'$. The latter is shown in detail in Fig. 10. It consists of a horseshoe magnet, M, upon which are mounted the coils, F, through which the vibratory currents from the line are made to pass. Opposite the poles of the magnet is placed the diaphragm, D, which has a platinum pin, C, mounted on its center. Resting upon this pin is another, B, which is attached to the end of a lever, which, together with the diaphragm, D, is in circuit with a sounder, S. A local battery is here shown in circuit merely for the sake of clearness, the current being in reality taken from the local leads of the dynamo.

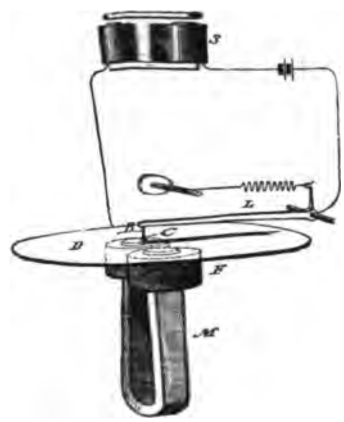


FIG. 10.—Condenser.

Now, when the key, K^2, is open, the armature of the transmitter, 3, is on its back stop, and closes a circuit including a 40-ohm resistance, so that the current from the vibratory generator is short-circuited and does not go out over the line. When the key, K^2, is depressed, however, the armature of 3 is attracted, breaks the short circuit, and the vibratory currents then pass out to the line. Arriving at the receiver, shown at 3, Fig. 8, they set the diaphragm, D, in rapid vibration, so that the pins, B and C, are given a rapid make-and-break motion; in fact, so rapid is the motion and so short a time are the pins in contact, that the local circuit is practically open, and the sounder has not time to act, being purposely made sluggish in its movements; the local circuit remains open, then, as long as the key, K^2, is depressed. The dots and dashes of the key are therefore received on the vibratory receiver as a series of "buzzes," which are transformed in the manner described into dots and dashes on the local sounder, S. Both the relays as well as the vibratory receiver are wound differentially, as in the ordinary duplex service.

The Edison Phonoplex.—The ordinary duplexing of a wire, which increases facilities between terminal points only, has been largely applied, but until Mr. Thomas A. Edison devised this new method of transmission no means were available by which the capacity of intermediate offices on a single Morse circuit could be increased. Through the use of the phonoplex system extra circuits are provided, by means of which more than double the amount of service may be derived from a single wire than is at present obtained, while its extreme simplicity of detail and adjustment places it within the easy control of ordinary operators.

The principle upon which the system is operated is induction. The instruments employed for signalling respond only to induced currents thrown upon the line by transmitting devices, which currents interfere in no way with Morse instruments in the same circuit, being made to pass around them through condensers, while Morse waves in turn have no perceptible effect upon the phonoplex apparatus; thus, two or more independent circuits may be provided on a single wire, as will be more fully explained hereafter.

FIG. 11.—The phone.

The apparatus for the equipment of an office consists of a key, transmitter, magnetic coil, small resistance box, and the phone, which last responds to incoming signals, two condensers, battery; and the whole is arranged to occupy no more space than ordinary Morse instruments. Fig. 11 represents the phone. A hollow column of brass resting upon a wooden base encloses the magnets. At the lower end is a rack and pinion by which these can be adjusted with reference to the diaphragm. To the center of the latter there is attached a screw-threaded pin with thumb-nut and binder at the top, and encircling the pin loosely is a split-hardened steel ring which rests upon the diaphragm. When the latter is snapped by the attraction of the momentary current in the magnet, it throws the ring violently against the stop nuts and produces a sharp, loud click,

relay designed by Mr. Phelps, and which is represented in Fig. 33. It will be seen to consist of two steel magnets, bent as shown, with their like poles brought together and carrying an extension piece which has a V-shaped groove at the top. The other ends of the magnets carry extension pole-pieces and fine wire helices. The armature is about the same thickness and size as a 3-cent nickel piece, but its lower edge is straight and thinned down to a knife edge, which rests in the bottom of the V-shaped groove. Thus we have friction entirely

FIG. 34.—Edison-Smith static train telegraph.

removed, while the small mass and leverage of the armature, together with the strong magnetic field in which it is placed, prevent its moving under shock or vibration. It responds, therefore, only to the impulses sent through the coils, and its action is very delicate in spite of its shock-resisting power.

Edison-Smith Static Train Telegraph.—While the Phelps train telegraph is actuated by dynamic induction, the Edison-Smith system is based upon static induction, the metal

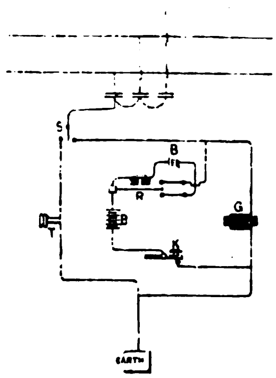


FIG. 35.—Station connections.

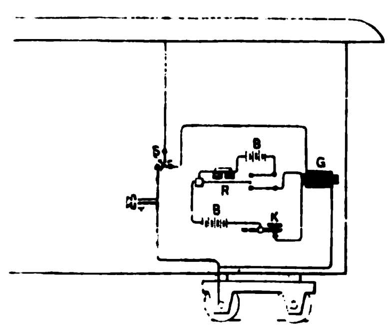


FIG. 36.—Car connections.

roofs of the cars being so charged that they act inductively upon the telegraph wires along the line, and thus render communication possible. In the same way the wires may act upon the roofs, and a message may be received on the train.

The arrangements of the car and the terminal station are quite simple and consist of a telephone receiver in lieu of a sounder, a Morse key, a vibrator, and an induction coil. Fig. 34 shows the operator seated at his desk, which has been installed in one of the passenger cars, and having two telephones to his ears while he receives a message.

Properties of Steel annealed after Different Kinds of Heat-treatment—Chatillon et Commentry.

Number.	Per cent. of carbon, estimated.	Tensile strength, pounds per square inch, when annealed after				Elastic limit, pounds per square inch, when annealed after				Elongation, per cent. in 8 inches, when annealed after			
		forging.	quenching in water.	quenching in oil.	quenching in lead.	forging.	quenching in water.	quenching in oil.	quenching in lead	forging.	quenching in water.	quenching in oil.	quenching in lead.
1	0·10	44,090	51,628	....	....	26,170	35,130	....	....	30	20	....	....
2	0·20	43,379	64,429	48,499	44,375	25,601	48,357	36,979	26,738	34	28	30	31
3	0·30	65.567	80,785	71,256	72,251	36,979	52,340	41,815	43,806	24	21	24	22
4	0·40	70,402	88,039	81,496	74,100	39,112	59,024	53,477	45,939	20	18	22	21
5	0·50	77,941	105,391	98,706	86,190	48,806	72,251	65,567	51,486	21	15	19·5	20·5
6	0·60	85,336	112,360	102,404	89,603	46,935	81,070	70,402	53,193	18	13	17	17
7	0·70	91,026	126,583	113,782	99,559	52,624	88,181	73,958	61,158	16	14	14	16
8	0·80	93,870	137,961	119,472	106,671	54,046	92,448	76,803	56,891	17	11	13	14
9	0·90	98,137	140,806	123,739	108,093	54,046	93,870	79,647	64,002	16	10	13	15
10	1·00	106,671	153,606	129,428	115,205	55,469	106,671	81,070	69,691	17	10·5	11	15
11	1·10	113,782	163,562	145,072	129,428	56,891	116,627	92,448	79,647	14	7	9·5	12
12	1·20	122,316	170,674	163,562	150,761	64,002	128,005	115,205	98,137	12	8	9	10
13	1·30	128,005	180,629	163,562	156,451	69,691	125,161	116,627	95,292	10	6	9	10

Thirteen sets of 1¼-in. square steel bars, apparently 8 in. long between marks, each set being of constant composition, are tested tensilely in four different conditions. These conditions are as follows:

(1) Simply annealed, apparently by slow cooling from dull redness after previous forging.

(2) Quenched in cold water from about a low yellow heat, then reheated to 750° F. (400° C.) and cooled slowly.

(3) The same, except that they are quenched in oil instead of water.

(4) The same, except that they are quenched in molten lead instead of water.

The proportion of carbon is approximately that given in the second column, and but little silicon, manganese, etc, is present—*i.e.*, the metal is true carbon steel.

Tempering Wheel: see Clay-working Machines.

TENONING MACHINES. Tenons may be made entirely with saws, or entirely with rotating cutters, or with a combination of both. Where cutters are used, one head may be made to cut a single, a double, or a treble tenon entire, at one operation. Where saws are used it is always necessary to have two sets. To cut a tenon with one cutter necessitates that the stick and the cutter-head shall have relative motion to each other parallel to the plane of the cheek of the tenon; the cutter projecting over the stick to an extent equal to the desired length of tenon. This motion of the stick or of the cutter-head in a plane parallel with the cheek of the tenon will, if the cutter has the proper outline, cut both cheeks, both shoulders, and the end of the tenon.

By the use of a single cutter having a central tongue projecting beyond the rest, there may be made a double tenon having no shoulders on the outside, but having any desired amount of shoulder between the two tongues.

Where two cutter-heads are used, their axes are parallel with the length of the stick, and the latter is fed in a direction at right angles to its own length and to that of the cutter mandrels. Each of these cutter-heads is practically making a gain or kerf, which has only one side, the side kerf making the shoulder of the tenon. The distance between the cutter-heads determines the thickness of the tenon; the height of the stick with respect to that of the mandrels, the shoulders. By raising the stick, or both the heads together, the shoulders may be made of the same width, or one wider than the other, with a fixed thickness of tenon. By keeping the stick in a plane parallel to those of the cutter-heads, but inclining it so that its length is inclined to those of the cutter mandrels, there may be made a tenon having a bevel shoulder; but the end will be square with the timber, as for ordinary use, unless the cutters are arranged one in advance of the other, and one of their mandrels bears a cutting-off disk; in which case there may be made a tenon having both the shoulder and the end beveled to the stick, but parallel to each other.

Tenoning machines producing their work by the action of cutters which remove chips have the advantage of doing work that is smooth in surface and of great accuracy in dimensions, but they consume more power than those which operate by saws. To cut tenons with saws there are required, to produce one double-shouldered tenon at one operation, two parallel mandrels, each bearing a cross-cut saw, and one bearing two ripping saws, the latter mandrel at right angles to the former two and to the stick. To make a tenon with

cutter for making double tenons. In working with this machine, the timber is placed on the carriage, which moves on rollers, and is passed between the tenoning heads, thus cutting one thick tenon ; it then goes on, and is brought into contact with the cutter-head upon the vertical shaft, which passes through the center, taking out a space according to the thickness

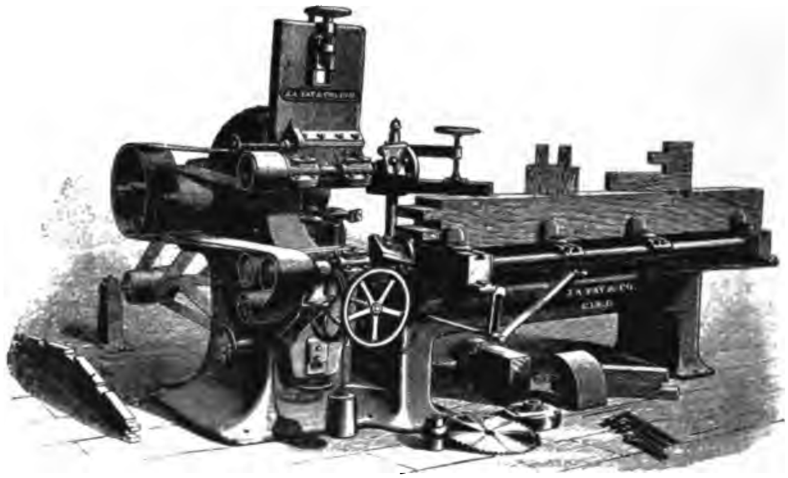


FIG. 2.—Gap-tenoning machine.

of cutter used, which completes the double tenon. There is a special attachment, independent of the tenoning part of the machine, for cutting gains, operating upon the under side of the timber, which is placed on the carriage and passed over the head. There is used an expanding head, that will cut from $\frac{1}{8}$ to 3 in. deep and from 2 to 4 in. wide. The countershaft that drives the vertical shaft and the gaining head is a part of

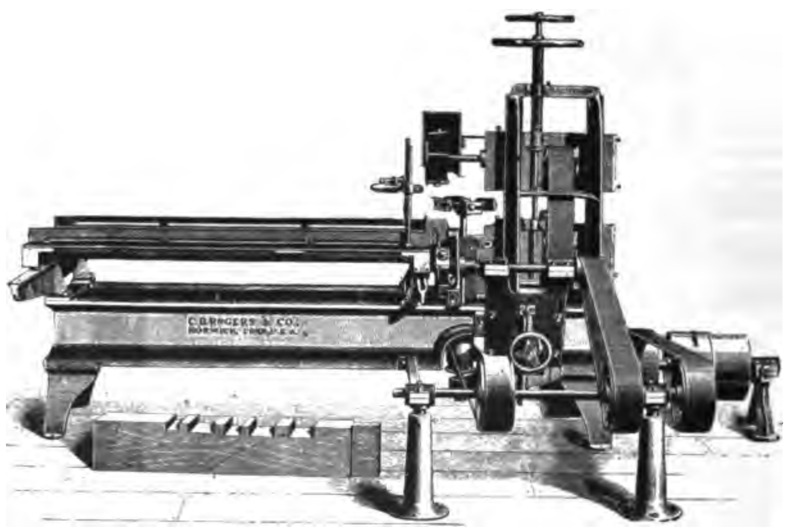


FIG. 3.—The Rogers tenoning machine.

the machine. When it is used as a gaining machine, it is worked from the back ; when used as a tenoning machine, from the front ; when it is being used as a gaining machine, the tenoning part is made idle simply by casting off the belt ; and the same way with the gainer head when the tenoner is in use.

The Egan Co.'s Tenoner Machine will make tenons on both ends of a stick at once, besides which, instead of making the tenons by the cutter-heads rather too long, and then cutting them off to the desired length, thus leaving a burr or ridge, it first cuts the stick to the proper length, and thus makes and finishes the tenons, leaving them with a smooth end finish.

of cut. The power to work these plane tenoning machines may be greatly increased by the use of rack and pinion gears. It is seldom that the foot is used in driving such machinery, the arm being more delicate as regards the adjustment.

II. Vertical Tenoning Machines.—*The Fay Car-tenoning Machine,* shown in Fig. 6, is for completing the tenon on large timbers for car work without reversal; and it will cut single, double, or triple tenons on both ends of long timber from one face without turning it end for end. This is done by a machine which presents the stick at right angles to two cutter mandrels and to the plane which contains them, but in this case the saddle containing the cutter-heads has a vertical traverse, and the tenon is vertical instead of horizontal. There are two tables, one before and the other back of the part bearing the cutter-saddle, and the stick is first clamped to the one before the cutters; the heads traverse down, cutting the tenon on one end; then the stick is shifted lengthwise to the table back of the cutters, and the heads traverse up, cutting the tenon on the other end of the stick. There is an adjustable fence for the thickness of the shoulder on the face side of the timber, and suitable gauges determine the length of the tenons. The head and attached moving parts are counterbalanced.

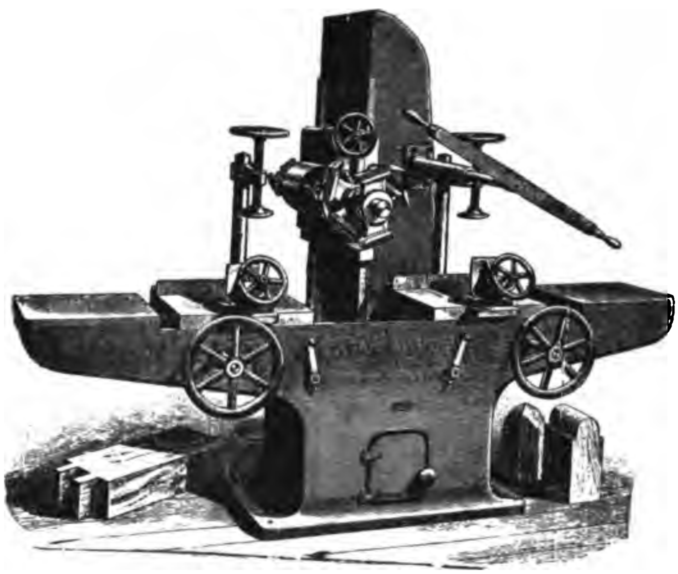


Fig. 6.—The Fay car-tenoning machine.

The Rogers Car-tenoning Machine, to cut double tenons, Fig. 7, is for work up to 16 in. square. There is a table on which the timber is laid, and that holds the timber in place by clamps, which are set by cranks in front. The bed adjusts to and from the double column of the machine by screws at the base, and has a movable section each side of the cutter-head for end adjustment of the timber to the cutters. The cutters are borne on a horizontal axis passing between the two columns at the back of the machine, and bolted from the back. The saddle carrying the cutter-head, which is counterbalanced, is raised and lowered by a large hand wheel. Hand wheels in front move the timber endwise, so as to bring the proper part of its length in contact with the cutters. The head is brought down, cutting as it goes, and passing into a recess in the table; then the timber is shifted lengthwise, and the head on the upward movement cuts the opposite end. There is a gauge by which the work may be set. The power stated as necessary to drive the machine is 8-horse, applied by an 8-in. belt.

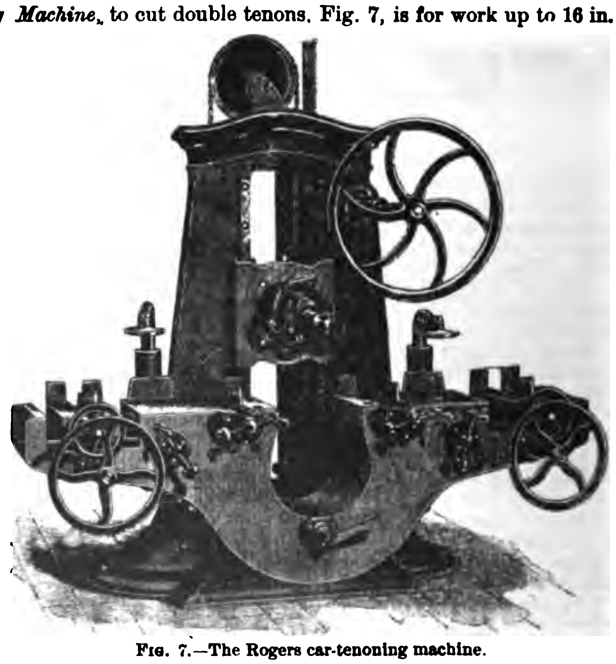


Fig. 7.—The Rogers car-tenoning machine.

special treatment, one of the machines for effecting a class of work which may be classed as dovetailing, and in some senses as tenoning, will be found described under the head of DOVETAILING.

TERRA COTTA LUMBER is the trade mark by usage and commercial name given to a composition of kaolinic clays and sawdust, in such proportions that, when the latter is burned out in the firing process, the brick residue is sufficiently porous or cellular to be profitably worked with carpenters' tools, constituting, in fact, a lumber indestructible by fire or age, and suitable to be used wherever pieces of not greater length than 2 or 3 ft. or less thickness than 1 in. can be employed. It is made up in various cellular shapes for building purposes, as shown in Fig. 1.

A large variety of porous earthenwares are now manufactured for structural uses. A

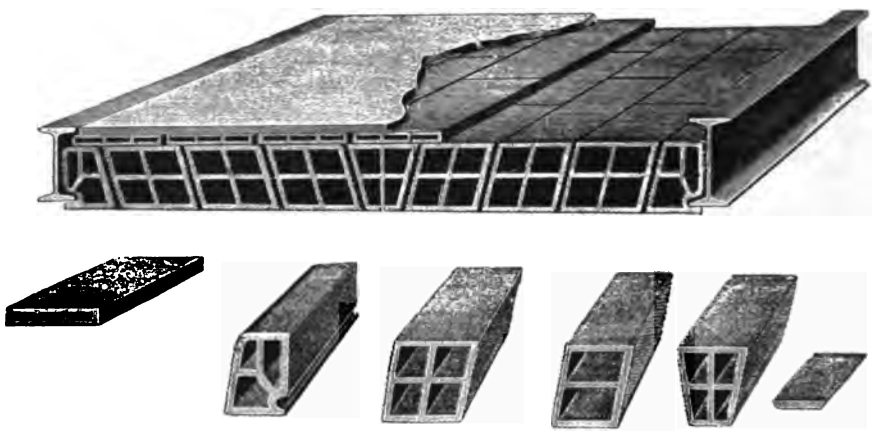


FIG. 1.—Terra cotta lumber.

comprehensive account of these will be found in a paper delivered by Mr. C. C. Gilman, before the Illinois Brick and Tile Association, at its convention, January, 1891. See *Scientific American Supplement* for May 30, 1891.

Tests of Engines: see articles under Engines. **Of Brakes**: see Brakes. **Of Pumps**: see Pumps, Reciprocating. **Of Boilers**: see Boilers, Steam. **Of Rope**: see Rope-making Machines. **Of Emery Wheels**: see Grinding, Emery. **Of Ice Machines**: see Ice-making Machines. **Of Locomotives**: see Locomotives. **Of Water Wheels**: see Water Wheels.

Threading Tools: see Tool Cutter, Lathe Tools, and Pipe Cutting.

THRESHING MACHINES. Threshers (colloquially "separators," because of the added duty of removing straw, chaff, and, to a great extent, grass seeds, weed seeds, and kernels of grain different in kind from the crop threshed) have remained for many years unchanged in main principles, but have far greater capacity and efficiency than formerly, and have some novel features added.

Fig. 1 is a representative improved American thresher and supplemental high stacker, made by Russell & Co., shown ready for work, the machine here represented traveling on the road by the locomotive power of the farm steam-engine used to furnish power when threshing. Specialist threshermen thus move the outfit from farm to farm, and thresh under contract for a fixed charge per bushel. For the interior arrangement of the same thresher see Fig. 2. It has, just beyond the threshing cylinder, a novel distributing "beater," consisting of a central tube with radial flanges arranged in spirals reversed from the middle circumference of the tube toward either end (Fig. 3). As the beater revolves, the central beaks of the flanges strike into the flying mass shot from the cylinder and distribute it the full width of the machine. The prominence of the flanges is so modified as they approach the sides of the machine as to equalize distribution and cause immediate separation to begin. This spiral beater is supplemented by the ordinary four-winged beater to whip the straw open, from which the mass of straw and grain falls upon the picker table, and then upon a series of lifting fingers to lightly toss it with a fan-like motion, imparted by rock shafts. The throw of the fingers is adjustable to suit the condition of the material threshed. Beyond these fingers is a series of connected alternating open pickers, with a tedder action, passing the straw onward while the kernels drop between them. Over the picker tail the straw falls 15 in. upon the extension table, which has a vertical motion at the first or lower end, and a vibrating motion at the other end, raising the straw on saw-tooth edges, but urging the grain kernels in, backward, down its inclined floor. Meanwhile a drag-up chain-elevator-way captures and returns to the threshing cylinder, up along the outside of machine, any incompletely threshed ears, to be rethreshed. To improve the cylinder spikes and enable them to stand the work of the high-speed machines of the day, a steel poll is welded upon a basis of tough iron (Fig. 4), greatly increasing the wearing quality of the tip

expert operators can do this by hand, and the labor is onerous, and usually very trying to

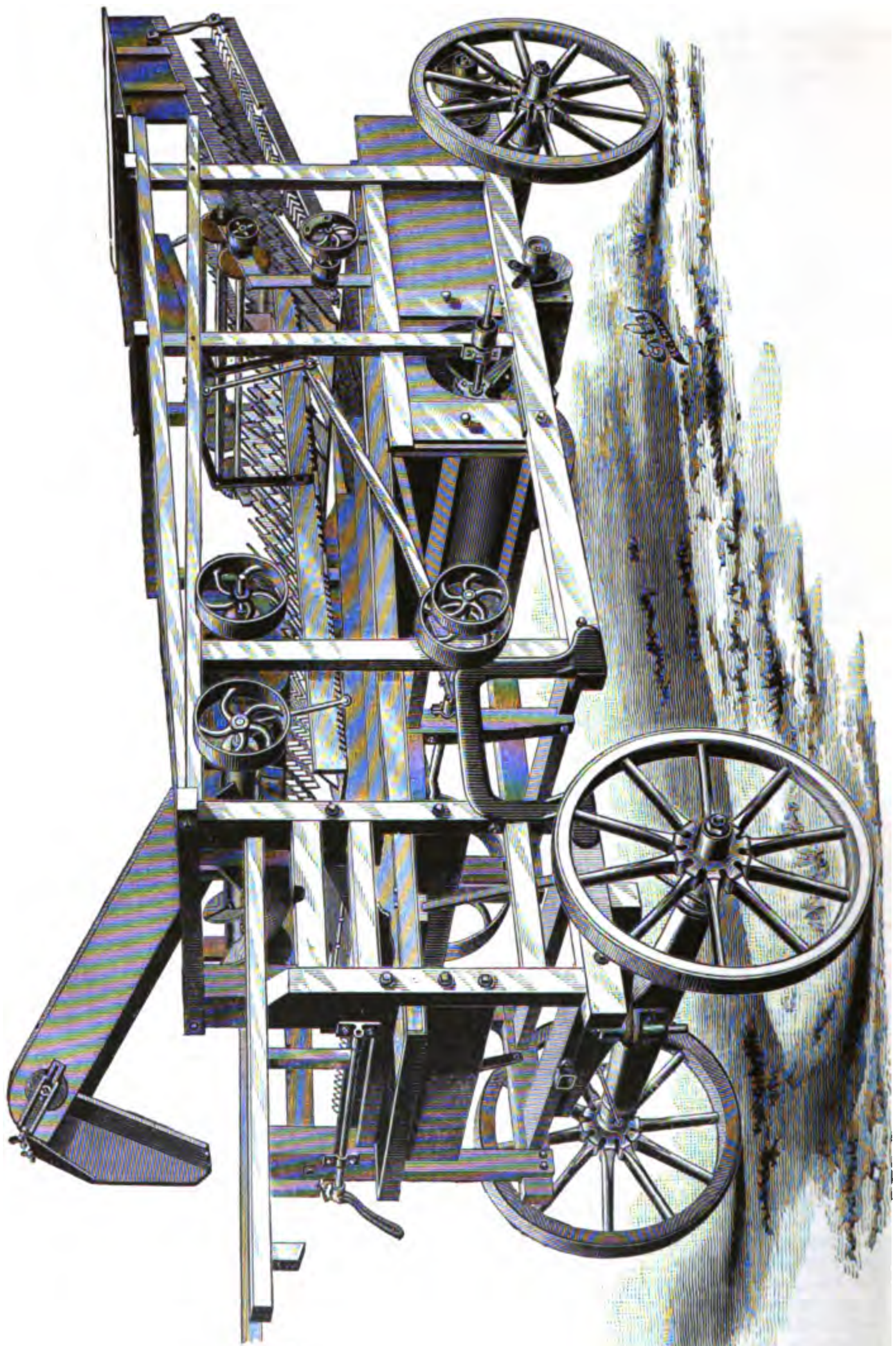


Fig. 2.—Thresher.

throat and lungs by reason of the fine dust which is thrown out from the machine ; an assistant is also required to stand by and cut the bands of the sheaves, and his position is danger-

ous. This attachment is provided with a row of belts which intercept the sheaves of grain delivered by a man with a pitchfork haphazard into the receiver, down the shake-table of which they are propelled by raking teeth fixed to its surface. This surface has a reciprocating movement longitudinally. A row of spring-teeth is adjustably suspended above

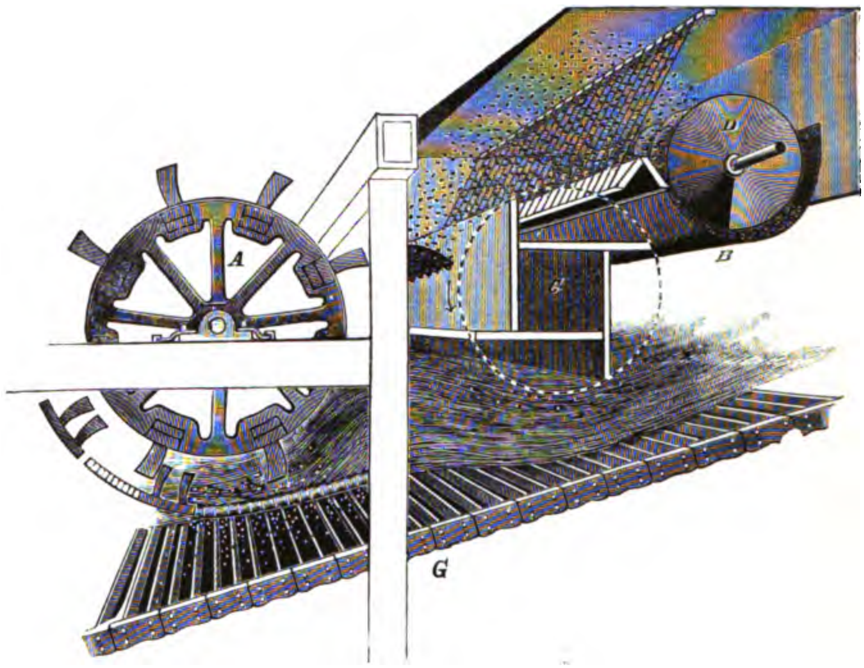


FIG. 7.—Pitt's thresher.

the descending stream of grain, to retard its upper stratum whenever it runs thicker than a determined gauge, while the shake-table uninterruptedly propels the lower stratum at a constant rate of speed into the thresher. A gang of half-moon vibrating knives cut the bands of the sheaves from above. It is made at Racine, Wis.

Trusser, for Threshing Machines.—Fig. 12 is a pair of twine-binding machines, of the

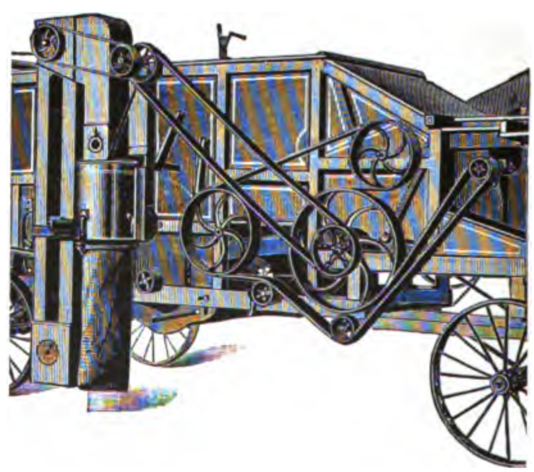


FIG. 8.—Thresher and bagger.

Appleby type, driven by one knotter shaft and one needle shaft for both, by a chain belt from the neighboring shaker spindle of a thresher. When the thresher presents sufficient threshed straw to fill the binder receptacles and trip either knotter, both are tripped in unison by its pressure on the trip lever; the needles rise and compress the straw into a long

ejecting each truss, ready for the next presentation of straw. In binding trusses of about 20 lbs. weight, the consumption of twine will be about 600 ft. to the ton of straw. The trusser can be applied to threshers of all patterns.

The "Cyclone" or Pneumatic stacker for threshers consists of revolving fans driven

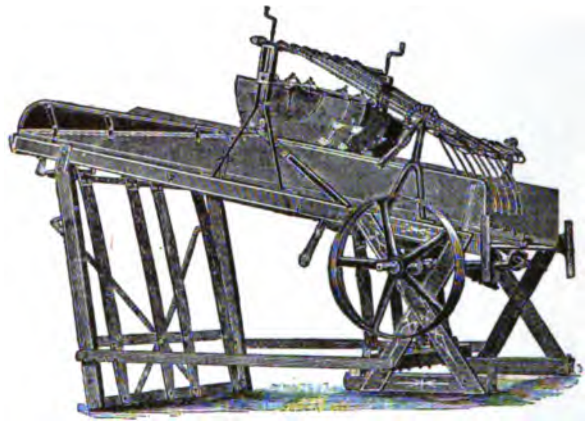


FIG. 10.—Automatic feeder for thresher.

from the thresher, and directing an air-blast into a receiving cylinder, from which straw and chaff pass through a pneumatic spout out upon the stack at any desired height as the

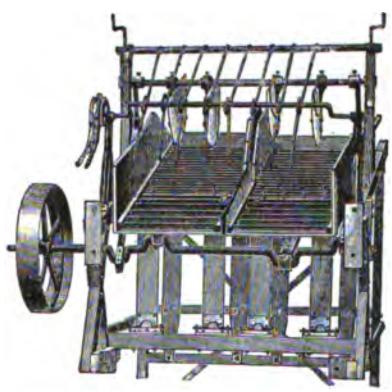


FIG. 11.—Automatic feeder for thresher.

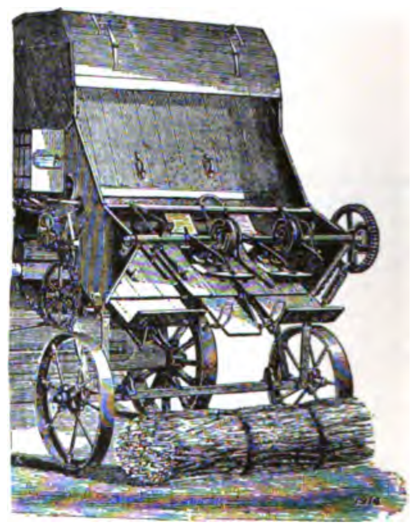


FIG. 12.—Trusser or binder.

growth of the stack progresses. The spout is swung automatically sidewise through an arc to form a long stack. The weight of this stacker complete is about 400 lbs.

Throating Machine : see Wheel-making Machines.

Ties : see Rails.

Tile Machines : see Brick Machines.

Tires : see Carriages and Wagons, and Rolls, Metal-working.

TORPEDOES. An examination of the details of vessels designed, built, and building in all the countries making any attempt to progress in this art, discloses the application of torpedoes to vessels of all classes and dimensions, from the smallest second-class torpedo-boat to the monstrous armored battle-ship. In addition to the boats being built by firms making that a specialty, naval constructors are giving particular attention to a ship of average dimensions to meet the requirements of torpedo warfare. The development has already carried us from second-class torpedo-boats, up through boats of the first class, Fig. 1, torpedo dispatch vessels, torpedo gunboats, to torpedo cruisers and torpedo depot ships.

For all naval warfare there is needed a torpedo possessing high speed, good range, as-

Dynamite Projectiles.—There are two types of projectiles thrown by the dynamite gun now in use, in various sizes, known as full-calibers and sub-calibers. The full-caliber, which fills the bore of the gun completely, consists of a light, strong case containing the explosive, fuse, etc., with a small tube in the rear supporting the rotating blades or vanes which control the direction of the flight. The case or body consists of a steel or iron tube ⅛ to $\frac{3}{16}$ in. thick, closed at the front end by a brass conoidal-shaped head, and at the rear by a hemispherical base casting of bronze. The base casting has a socket in the center to attach a small tube that supports the rotating blades. Eight blocks of vulcanized fiber, on each end of the shell, center it in the bore, causing thereby friction, heat, vibration, etc.

Shells for a 15-in. gun are usually about 10 ft. long over all, the body being about 7 ft. and the rear extension 3 ft. These have a total weight, when filled, of 1,000 lbs., and contain 500 lbs. of explosive. The fuse is placed either in the point or base, according to its design. The sub-caliber projectiles are smaller in diameter than the bore of the gun, and have no rear extension carrying rotating blades. The blades are attached directly to the body, near the rear end. They occupy a portion of the space between the body of the shell and the bore of the gun, at the same time serving to center the rear end of the shell in the bore. The front end is centered by four wooden blocks which drop off as soon as the shell leaves the muzzle. They are held in place by pins entering into the shell. A wooden disk or gas check is placed in rear of the projectile, filling the bore completely, and preventing any escape of air.

The body of the projectile is made up similarly to the full-caliber, except that the charge only fills about three-fourths of it, the remaining space at the rear being left empty. This is done to keep the center of gravity forward of the center of figure, and so maintain steadiness of flight. Sub-caliber shells 6 in. in diameter, and about 6 ft. long, weighing, filled, 150 lbs., contain a charge of 50 lbs.; those 8 in. in diameter, 6 ft. 5 in. long, weighing, filled, 300 lbs., contain a charge of 100 lbs.; and those 10 in. in diameter, 7 ft. 8 in. long, weighing, filled, 500 lbs., contain a charge of 200 lbs.

Fuses of various kinds have been used the most noted being Captain Zalinski's electrical fuse. It consists of two fuses, one to act instantaneously upon striking a solid target, such as the hull of a ship; the other to act upon entering the water, either instantly or after some seconds of delay. The first may be called an impact fuse, and the second an immersion fuse. The former consists of a battery containing liquid, ready for action, connected through a "low tension" primer. Upon striking the target, the circuit is closed and the primer exploded. This explodes the detonating charge of dry gun-cotton or dynamite, and that in turn explodes the whole charge. In case the shell misses the target and enters the water, the immersion fuse acts. This is similar to the other except that the battery contains no exciting liquid—is perfectly dry. As the shell enters the salt water, the battery becomes wet and active, which immediately causes explosion, unless a delay is desired, in which case a powder train is used. Mechanical fuses have been sometimes used. These generally act by impact either against a solid target or the water. An ingenious fuse of this class was designed by Mr. H. P. Merriam. One of its most peculiar features is a small wind-mill at the point of the shell, which unlocks the firing hammer as the shell passes through the air. It has two sets of caps, one intended to act when the shell strikes a solid target, the other when it strikes the water. The water enters an opening in the point and presses a plunger backward, driving the caps against the hammer, which in this case is a steel ball. When a solid target is struck, the point of the shell is crushed in, thus firing a set of caps arranged inside. Delay action can be given by a powder train.

The projectiles are not designed for penetration, but at Shoeburyness in England, a 10-in. sub-caliber, weighing 500 lbs., was fired into a butt of sand, situated 600 yds. from the gun, and it penetrated 47 ft. The accuracy of fire is very remarkable, even when compared with modern rifles. The following table is a record of the ranges and deviations obtained at Shoeburyness during experiments by the English Government.

8-in. Sub-calibers. Initial Pressure, 1,000 lbs. Wind, 8 ft. per second.

Number of round.	Elevation.	Range.	Deviation from line of fire.
1	20°	3,647 yards.	17·2 yards left.
2	"	3,648 "	20·8 "
3	"	3,647 "	18·6 "
4	"	3,640 "	22·6 "
5	"	3,644 "	21·2 "

See GUN, DYNAMITE.

II. SUBMARINE MINES.—Some of the most important improvements in submarine mining are the following: The modern high explosives and smokeless powders have largely superseded gunpowder, making it possible to have much less bulk, while retaining an equal amount of explosive force. It can readily be seen that this is an extremely important consideration, since upon the size of the torpedo depends the depressing effect of the current; hence the amount of buoyancy necessary to keep the case always high enough to be touched by an enemy's vessels in passing. This buoyancy regulates the weight of anchors and mooring connections that hold the buoys in place, and in fact the principal dimensions of the system.

largely experimented with in this country, and is now being made in France as well as in the United States.

The Victoria Torpedo, Fig. 4, is designed for both coast defense and ships' use. The forward compartment contains the explosive charge in its lower part, and Holme's light composition in the upper. The depth, when running, is controlled by a horizontal rudder, actuated by a pendulum and servo-motor. In rear of this is the electrical cable chamber, containing 1,200 yards of cable. Vertical steering rudders are controlled by a motor in the rear part of the torpedo. An arrangement is also made by which the torpedo can be launched from fixed under-water positions well clear of the shore, a buoy containing cable being sent with the torpedo. To operate the torpedo from such a position, it is started off, pulling cable out of the buoy, the starting effected by means of cable connection with the shore.

V. Automobile, or Fish Torpedoes.—*The Whitehead Automobile Torpedo* consists of a cigar-shaped envelope of steel or phosphor bronze, containing six compartments for its propelling, directing, and exploding mechanism. Its motive power is compressed air; it is propelled by two two-bladed screws, revolving in opposite directions about the same axis, in order to neutralize their individual tendencies to produce lateral deviation; and it is maintained at a constant depth by horizontal rudders, and on a straight course by vertical vanes set at an angle predetermined by experiment. The forward compartment contains the explosive cartridge and the firing arrangements. The cartridge is made of disks of wet gun cotton, contained in a metallic case, shaped to fit the chamber, and held in place by a felt buffer. The cartridge primer is made of dry gun cotton, and is inserted in the hole in the center of the disks. The detonating primer contains fulminate of mercury, protected from moisture by gumlac. The firing arrangement is made up of a small propeller, working in a sleeve, in rear of which is the firing pin, held in place by a lead safety-pin. The arrangement is such that when the firing gear is taken from the torpedo, the cartridge primer goes with it, rendering the torpedo inoffensive.

The immersion regulators are contained in the "secret chamber," and their office is to control the horizontal rudder after launching, so as to bring the torpedo to a predetermined immersion, and keep it there during its flight. The pressure of water due to depth below the surface acts against a piston, the motions of which are communicated to the horizontal rudders, so that, when the torpedo is below its plane of immersion, the increased pressure will elevate the rudders, and when it is above, the decreased pressure will depress them. When the torpedo is in its plane of immersion the piston is kept in mid-position by an equilibrium between the pressure of the water and the tension of three steel springs. A pendulum works in connection with the above apparatus, so that should the rudders be "hard up," and the torpedo in consequence turn its nose up, the pendulum would swing gradually aft, reducing the rudder angle until the action of the piston has been neutralized, and the rudders are straight.

The impulses of the mechanism in the secret chamber are insufficient to move, unaided, the numerous cranks and rods connecting it with the horizontal rudder. A device called a *servo-motor* is, therefore, interposed, so that the impulses of the regulators are transmitted only to a valve in the machinery chamber, and by the motion of this valve, augmented impulses are transmitted to the rudder rods by means of compressed air from the reservoir, which latter is made of cast-steel forged on a mandrel. A Brotherhood or Whitehead engine, having three cylinders fixed radially upon the shaft, works the propelling machinery. The compressed air is admitted behind the pistons, and evacuated in proper order by three slide valves. The buoyancy chamber is an air-tight compartment, the use of which is to give a certain preponderance of buoyancy to the torpedo during its flight, to insure its returning to the surface, or, by flooding the chamber, to cause it to sink. The bevel-gear chamber comes next, and contains the gearing for making the propellers revolve in opposite directions. Next comes the tail of the torpedo, consisting of the rudder support and the rudders, both vertical and horizontal.

The launching apparatus consists of a torpedo tube, closed at its outer end by a sluice door, and either permanently set into the ship's side, or fitted with a ball-and-socket joint for lateral train, or on trucks for transporting. This tube encases a sliding bronze shield, which, by means of compressed air, can be made to slide in and out on rollers. A hinged door at the breech of the tube is opened, and the torpedo pushed forward into the shield until it brings up against a stopper; a strut, pushed in after the torpedo, prevents any motion to the rear. When the torpedo is set free, the shield doors are all open, and the inrushing water, exerting an equal lateral pressure, simply presses the torpedo directly sidewise aft, without deflecting it at an angle from the desired course. The 18-in. Whiteheads have a speed of from 32 to 33 knots for 437 yards, and 30 knots for 875 yards.

The Howell Torpedo.—The general profile of the Howell torpedo, Fig. 5, is that of a spindle of revolution, the after body being a true spindle, the middle body a cylinder, and the fore body an approach to an ogive. There are four detachable sections. The first (*a*) is the nose, carrying the firing pin and its mechanism. The latter is permanently fixed in a hollow bronze casting, attached to the front end by a bayonet catch for ready handling. The outer end of the firing pin is provided with fan-shaped corrugated horns, to prevent glancing or sliding along the object struck. The condition of the firing pin is at all times plainly visible, its length beyond the nose showing whether it is cocked or not. The dummy and the fighting heads are both made of sheet brass, the former being the lighter, so as to give about 13 lbs. buoyancy. In the fighting head the main part is filled with wet gun cotton (*b*),

TRAPS, STEAM. *The Thoens Balanced Steam Trap*, shown in Fig. 1, consists of a cast-iron casing, enclosing a galvanized-iron float, open at the top. To the bottom of the float is attached a sleeve, with a valve seat, which is fitted around a vertical pipe. The latter is fastened to the base of the trap, and connects with the outlet pipe. This vertical pipe is provided with openings at the upper end to discharge the water from the float. As the condensed water accumulates in the trap, the float rises, and the sleeve closes the openings in the vertical pipe until the water overflows the top of the float, when the weight of the water

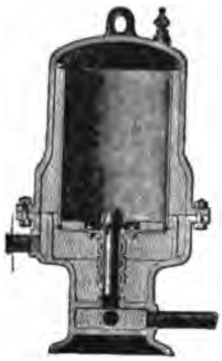


FIG. 1.—Balanced steam trap.

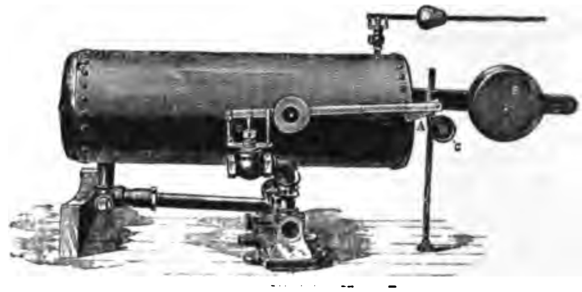


FIG. 2.—The Morehead steam trap.

depresses the float, allowing the water to pass out through the openings in the vertical pipe to the discharge pipe until the float becomes light enough to rise again, when the operation is repeated.

The Morehead Steam Trap, shown in Fig. 2, consists, as shown, of a tank so supported as to be free to tilt upon a bearing between the two check valves, the nearer of which is marked *F*. The open end of the valve, *D*, is connected with the steam dome of the boiler. The water of condensation, returning through the check valve, *F*, enters the tank; and when a sufficient accumulation has taken place to overcome the effect of the weight, *B*, the trap will tilt until the left-hand end is received in the hollow block below. In a socket in the arm carrying the weight, *B*, is secured a standard, upon which is a roller, *C*. When the trap tilts, this roller is brought against the end of the lever of the valve, *D*, raising the valve and admitting steam from the boiler to the interior of the trap. The pressure thus being the same upon the surface of the water as that in the boiler, the water descends by its own gravity, entering the boiler through the check valve opposite *F*. When the trap is emptied, the weight, *B*, returns it again to the position shown in engraving, in which it is supported by the standard, carrying the roller, *C*. The valve lever is attached to a rod, which engages with the base, so that when the trap is in the position shown, the valve connected with that lever will be open, relieving any pressure inside the trap. When, however, the trap tilts again, this valve is seated by the weight upon the lever.

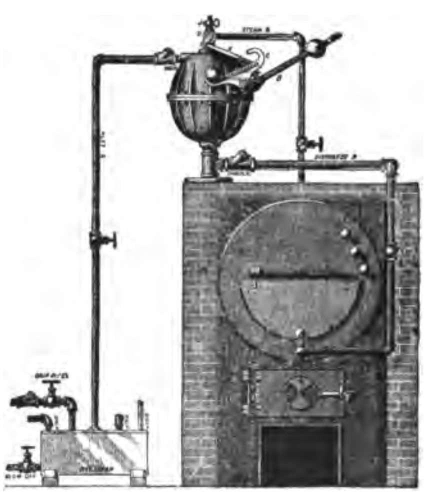


FIG. 3.—Pratt's steam trap.

Pratt's Return Steam Trap, shown in Fig. 3, has a receiving vessel, inside of which is a water-tight cast-iron float, suspended on one end of a lever. The other end of this lever is fast to a spindle passing through a stuffing-box, and carrying on its outer end a lever with a weight, which counterpoises half the weight of the float. A rocking lever is provided with a weight, which rolls to either end, alternately, as the feeder fills and is emptied of water, the rolling ball acting at exactly the same point every time to open and close the steam valve.

Tricycle: see Cycle.
Trimmer: see Book-binding Machines.
Tripod: see Drills, Rock.
Trucks, Fire: see Fire Appliances.
Trusser: see Threshing Machines.

The Thorne Typesetting Machine, of which there are a large number in use, has been lately remodeled and improved, and is now considered to be a practically perfect newspaper machine, combining the features of typesetting and the automatic distribution of the type after it has been used, back into the machine for repeated use. A general description of the machine, which is shown in the accompanying illustration, is as follows: As will be seen on reference to the general view, Fig. 1, the two principal features of the Thorne typesetting and distributing machine are a keyboard, and two vertical cylinders, having the same axis, the upper cylinder resting upon a collar on the lower one. Both cylinders are cut with a number of vertical grooves, of such form as to receive the type, which is to be first distributed, and then reset. There are ninety of these vertical grooves in each of the cylinders, sufficient to contain all letters, and all kinds of characters that are wanted for ordinary purposes. The keyboard carries a number of keys corresponding to that of the grooves, and when the machine is in operation, whatever key is depressed, the letter corresponding to it is ejected from its proper groove in the lower cylinder upon a circular and revolving table, which has the same axis as the cylinder, but is of larger diameter. Of course, quite a number of types may thus be ejected from the grooves in each revolution of the disk, and all are brought round in their proper order to a point of delivery, where they are conveyed by a traveling band into a guide, and are forced into a parallel position with each other and proper alignment by a striker as they travel in the guide, and they are also gradually turned upward by a twisted portion of the slide; that is to say, so as to present the face of the letters upward.

The types thus set are discharged in lines into a galley, and by an attendant, provided with a case containing "spaces," are "justified;" that is to say, the spaces between words are increased equally until the last word, or, if a syllable, with its required hyphen, in each line reaches the end of the line. Proof corrections are, of course, done in the ordinary way.

The control of the types is effected by forming on the side of each character recesses something like the wards of a key, the arrangement, of course, being different for each character. The upper ends of the grooves in the lower cylinder are provided with projections corresponding to these grooves on the types, so that no type will fall into any groove other than that for which it is intended. This arrangement applies only to the lower cylinder, which does not revolve. The grooves in the upper or distributing cylinder are large enough to receive all the types, indifferently, that are fed into them. The work of distribution is effected as follows: A suitable attachment to the side of the upper cylinder enables the operator to place the galley containing the type to be distributed in contact with the cylinder, and by a very simple device, line after line of type is fed into the cylinder until, if desired, every groove is nearly filled, and the upper cylinder is caused to revolve upon the lower one, with which it is in contact. As the columns of mixed type pass over the heads of the differently shaped grooves of the lower cylinder, letter by letter falls into its proper groove as soon as the nicks in the types find their corresponding wards.

This machine, it will be seen, requires accuracy in construction, as do also the types that are used with it, and this has been reduced to an exact system. The types prepared by casting in the usual manner, are set in line, clamped in a slide, and the lines of notches or grooves upon the edges are plowed or planed in them; the accuracy of the tools employed in these operations determines the accuracy and perfect working of the machine. The grooves have been cast in the characters in several cases. By the use of this machine, types made in the highest perfection of type founding are used, which is not the case in the type of stereotyping or line casting, because the differences in the form or character of different parts of the same font of letters demand for the best perfection differences of temperature and of metal, which are regulated by the skill and care of the workmen in making the type.

In handling the type by this machine, contact of the face of the letter with any of the parts of the machine is avoided, so that the best possible typography is secured by it. The only apparatus or adjunct requisite for this machine is steam power, or other propelling power. As compared with other machines requiring the melting and cooling of metals, and electric batteries for checking errors arising from the derangement of the machine, and air currents for imparting motion to matrices, or other equivalent parts, it is said to be simpler and superior. The use of these machines involves the expense of the wages of these operatives, to-wit: One compositor, one justifier, and one boy for distribution, per machine, and one man to set the head lines for a number of machines.

The Lanston Type Machine belongs to a new class in the typographical art. It is, in fact, "a machine that reads copy, and automatically rewrites it in type metal." By means of the devices invented by Mr. Tolbert Lanston, the functions of the type caster and the compositor are combined in a single mechanical process, the type metal being transferred from the crucible to the galley in the form of composed type, ready for the press. The only manual part of the work is the manipulation of a keyboard, operated independently as to time and place from the type machine proper, the movements of the latter being entirely automatic. This keyboard contains a separate key for every character and space type contained in a complete font. They are 225 in number in the machine now in use, and these are arranged in a bank of 15 rows, of 15 keys each. The depression of any key punches a round hole in a paper ribbon. When the last syllable which can be put in any line has been recorded by these holes in the paper ribbon, the extent to which the spaces of that line must be varied (by being made either smaller or larger) to justify the line, is indicated by a scale, and a record of the degree of variance is made by means of holes punched in singly in the paper. The roll of paper ribbon having been filled with such holes punched at definite close intervals along its length, is next transferred to the type machine proper. It is evident that

the various wires and matrix bars is swung down into position, with its front leg resting on a base formed on the center shaft, as seen in Fig. 2, and the compressing arm is swung to the left of the path of movement of the matrix bars ; the latter, by the key action mentioned, form the line of composition in front of the mold, the latches retaining the matrix bars having their appropriate lips inserted between any two matrix bars by reason of inclines on the latter, so as to cause the release from the latches of only the proper matrix bars. When the desired line has been thus formed, the operator desists from further key manipulation, and gives the treadle its primary stroke.

This operates, first, to bring the compressing arm into position parallel with the line of composition, and to a predetermined point positively fixed for the length of the line when it is finally justified ; second, to rotate and move longitudinally a space shaft, which causes disk sections of the compound spaces to move together to cause the spaces to expand the line of composition to the full extent as limited by the set position of the compressing arm ; third, to move the mold slide toward the line of justified composition, said mold slide carrying the aligning plate, which engages with the matrix bars to place their matrices in line, and the slide also operates a space supporter so that the latter may provide rear bearing for the spaces as they are pressed at their forward edges by the mold ; fourth, to swing the melting pot forward and upward so that its discharge conduit will register tightly against the casting chamber ; fifth, to actuate the pump plunger in discharging the molten type metal into the casting chamber.

The production of each cast type bar is caused by one complete revolution of the main driving shaft, subdivided into two semi-revolutions in the same direction, respectively a primary and secondary movement, so that each said complete revolution of the main shaft is the result of two full-stroke movements of the treadle. After a brief duration, sufficient to ensure the cooling and proper setting of the cast type bar, the treadle is given its secondary movement. This rotates the driving shaft the final half of its revolution, which acts to, first, withdraw the plunger of the pump; second, to withdraw the melting-pot discharge conduit from the casting chamber ; third, to move the mold slide toward the left of the machine, thereby releasing the line of composition from pressure of the mold, releasing the spaces from the pressure of the space supporter, swinging up the upper mold section, and actuating the mechanism which ejects the type bar from the casting chamber ; fourth, to rotate the space shaft in reverse to its previous movement, and place the connecting mechanism in suitable position for a repetition of the operation described under the first treadle movement ; fifth, to move the compressor shaft rearwardly, and throw its arm out of the path of movement of the matrix bars in reverse to its first described movement.

The matrix carrier can then be swung backwardly, so as to distribute the matrix bars which were previously in the line of composition ; each travels back to its own place by gravity, and the spaces which were in the same line may be moved by the space distributor rearwardly, and off from the space shaft, on to a space way, and upwardly on the latter until they are locked by a special latch. The cast type bar, which constitutes the product of the above-described operation, is then ready for trimming, which is done by mechanism operated automatically by means of connections with the treadles and main driving shaft.

The length of line and body of the type bar may be altered very quickly, and the machine may be converted from a minion to a nonpareil, or to any other face for which extra sets of matrices and extra casting boxes may be supplied. An eight-page section of the New York Sunday *World* was, with the exception of the displayed advertisements and heads, set up on a Rogers typograph. The composition was done entirely on one machine, by three operators, working in turn, 8 hours at a time, in 4 days, 23 hours, and 35 minutes, in which time the proof was read, corrections were made, the heads set, and the type placed in chases and made ready for stereotyping, by the same operators, at a total cost of $67.22, the operators being paid at the rate of $27 a week, the regular rate for time work on morning newspapers set by the "piece" in this city. This work, had it been done by hand, it is estimated, would have cost, including time, making ready, and proof reading, $173.01. A speed of over 7,000 ems an hour has been attained in setting memorized matter on a sixteen-em pica line, minion machine, and this seems likely to be excelled.

The Linotype (*Mergenthaler's patent*) is a machine now extensively used, and which enables an operator working at a keyboard attached to the machine to set lines of type of any required length ; such lines, upon completion and perfect justification mechanically, are then cast as solid lines, and dropped into a galley while the succeeding line is being set and justified. The linotype has a keyboard of 107 separate keys, arranged in six rows, and this number of keys is said to be sufficient to cover not only all required faces of type to be used as from one font, but also, on some machines, to meet the requirements of many logotypes with faces set bodyways, such logotypes being much used in printing addresses for wrappers, thus : Mr. John Jones : the twelve months, expressed by three letters each, Jan , Feb., Mar., etc. ; Mr., Mrs., Dr., Prof., etc., to the extent perhaps of 20 additional keys. The fundamental parts of the machine are a series of female type or matrices, each containing a single letter or character, and a series of spacing devices or guides, each of which is capable of movement to variable thickness. The assorted matrices are arranged in the channels of a magazine, provided with escapement devices connected with finger keys, so that the operation of a key is followed by the discharge of a matrix bearing the same character. The space bars are arranged in a magazine, and discharged in like manner.

the ribs, and when the matrix reaches a point directly over its appropriate channel, all of its teeth are, for the first time, disengaged, and it is permitted to descend by gravity into the magazine, there to remain until all of its predecessors in that channel have been called into use.

A simple mechanism is provided for transferring the matrices, one at a time, in rapid succession, to the distributor bar, and for carrying them along the bar to the points of discharge. The organization of the machine is such that the manipulation of the keys to assemble the characters for one line, the casting of the preceding line, and the distribution of a still earlier line, are carried on concurrently and independently. The machine is operated by a small expenditure of power. Its principal parts move slowly, and the task of the operator is limited to the manipulation of the finger-keys and the simple movement required to start the line. As soon as one line is completed and started to the caster, he proceeds to set up another line. The keys are operated with a lighter touch than those of a typewriter. The capacity of this machine, as now speeded, is from 8,000 to 10,000 ems per hour.

Fig. 8 is a perspective of the complete Mergenthaler linotype machine.

The Munson Method of Power Type Composition has been recently simplified and improved, so that features formerly criticised or excepted to by practical printers have been eliminated. It has been considered that most of the typesetting and composing machines heretofore placed before the public were limited in their capacity for work by the ability of the operator, and that, with the average manipulation, from one-half to three-quarters of the capacity of a well-constructed machine remains idle. The object of Mr. Munson's inventions is to overcome this defect in typesetting machinery, and to make it possible to work up to the absolute maximum speed. He uses three machines, viz.: A preparatory perforating machine, a typesetting machine, and a type-distributing machine. The preparatory perforating machine is small and simply constructed. It is provided with a keyboard that can be worked by any typewriter operator at any time or in any place, and the result (a strip of paper having a series of transverse rows of perforations) can afterward be used to operate the typesetting machine. By this plan two, three, or possibly more persons can be employed simultaneously in keeping one typesetting machine constantly at work. This preparatory or "compositor's" machine works as follows: To each letter, point, figure, space, quadrat, etc., is assigned a particular row of perforations in the ribbon, the rows being made to differ from one another by changes in the combinations of their perforations. The operator has only to see that he depresses the proper keys in their right order, the machine itself taking care of the combinations and insuring the correct perforations of the ribbon. The operator determines as he goes along where each column line of type shall end, in substantially the same way that a typewriter operator decides where each line of typewriting shall end. That is, he is guided by an index moving along a graduated scale, and also by the sound of a bell that is struck automatically a little before the end of the line is reached, just as the typewriter operator is guided by the "carriage scale" index and bell of that machine. When the end of a column line is thus fixed upon by the operator (whether the division comes after a word, after a hyphen dividing a word, or after a point, figure, or other character), he marks the terminus of the line by touching a key that causes to be inserted at that point in the ribbon a row of perforations that represents a peculiar type, called the "line divider." He then proceeds in like manner to compose the next line.

The typesetting machine has no keyboard, but is automatic in its action, and is operated entirely by mechanical power, its work being directed by the perforated strip. Automatically it does the following things: (1) It sets matter in a long, continuous line of type, this line consisting of a succession of separated short lines, each of which has the requisite length and the proper terminal division to make it, when spaced and justified, a correct and suitable column line. (2) It spaces evenly, and justifies with exactness each of such column lines, and then deposits it with the column of type on the galley. (3) When matter is required to be leaded, it inserts leads between the lines of type as they are moved on to the galley.

The type used with these machines is the ordinary type made and sold by typefounders. The power type distributor is entirely automatic; that is, it will not require the "dead" matter for distribution to be fed into it by hand, but a whole page or column of type may be placed on its table, and the machine itself will do the rest. It separates the foremost line of type from the others, and then picks off each individual type and places it in its proper reservoir.

The Electric Linotype Machine, based upon the inventions of Mr. Shuckers, and further improved by Mr. Homer Lee, is an automatic type-bar casting machine, differing from the Mergenthaler and Rogers machines in that, instead of using female characters of the matrix order, it employs male or cameo characters secured to the ends of bars arranged in the arc of a circle over a key-assembling channel, the bars being arranged in lines radial to their key channel. Any number of bars with like characters may be used. The bars are released, one at a time, by electro-magnets operated from a keyboard. When released, each bar falls by gravity with its type end in place in the assembling channel in front of the operator, each succeeding bar, as it falls, taking its place alongside of the preceding bar. The automatic justifying spaces are similarly released by a proper key and electro-magnet to fall in place between the type bars, and when the line is completed the machine automatically clamps the types in place, and at the same time moves the justifying spaces simultaneously all to equal distances, so that the line is automatically justified at the time it is clamped rigidly in place. The soft lead bar is then fed beneath the line of clamped type bars, and is moved up into forcible

when they are depressed the same motion is given to it, and in turn carried forward to the rocker bar, which receives a ¼-in. vibration at its upper part. In the middle upper part of the rocker bar a dog is pinioned, which engages the teeth of a double rack hung directly over it from the carriage. A driving arm is connected to a strong torsion spring underneath the machine, and then in turn to the forward rack, by means of an ordinary link and stud, so that there is a continual pressure upon the rack and carriage from right to left. The dog engages the rear rack when the machine is at rest. The two racks have an independent action within the limits of one rack tooth. Between the two is a small spiral spring, which, when the machine is at rest, is stretched by the stronger tension of the torsion spring; thus when the dog engages the teeth of the front rack, the strain is taken from the rack spring, which resumes its normal position, carrying the rear rack with it the distance of one tooth. In this way, the teeth of one rack are always opposite those of the other, and the dog plays back and forth, allowing the carriage to travel easily onward one space at a time. The vibration of the rocker bar gives the forward and back action to the dog, which engages first one rack and then the other.

At each side of the rocker bar is attached a pawl, engaging the teeth of a ribbon ratchet, which works on an eccentric giving a lateral movement to the ribbon. The ratchet is at one end of a short shaft, having at the other a small cog, geared to a larger one. The larger cog is pinioned to another shaft, which, as it turns, reels the ribbon. The shafts are at right angles, and, working together, give the ribbon two movements, thus exposing at the printing point a fresh part of the ribbon for each type impression. Thus a positive ribbon movement is secured, and the whole printing surface of the ribbon is utilized. By means of a switch at the back, the cogs at either side of the machine may be thrown in and out of gear at pleasure. Thus when the ribbon has been wound upon one spool, the switch is reversed and it is reeled upon the other. The lateral motion continues when either is in operation.

The keyboard, which consists of 78 characters, is so arranged that the letters most frequently used are most conveniently placed, and those least often used are in less prominent positions. The small letters occupy an oblong space in the center, about 7 in. long and 2¼ in. wide, distributed over three banks. Directly above the small letters, are six characters in common use; above these are the numerals. Below the small letters are the different punctuation marks, and at the right and left appear capitals, which are white upon a black background. It is designed that the left hand shall operate "*e*," "*f*," "*n*," and those at the left of them, and that the right hand shall operate "*y*," "*g*," "*l*," and those at the right of them. With this as the dividing line, the letters are arranged as far as possible so that in the majority of words the hands will work alternately in producing the letters, which is essential for rapid work. The keys are made from a composition which is easy to the touch, and from its dull luster is not trying to the eyes. Six bridges reach from one side of the frame to the other, through which key-stems pass, serving as a guide to them. Below, the stems are joined to equalized levers, which are made to operate type bars by means of long connecting rods. Hangers radiating from the center of the basket are attached to the top plate, supporting other levers. These are the type bars, which, being struck up from sheet steel, are hollow, thus securing lightness and strength. A conical bearing, which is tightened by an adjusting screw, insures a positive and permanent alignment. The type are set at the extreme end of the bars, affording a leverage of such power that by means of impression paper 40 copies can be made at once. For this reason the Caligraph is used by press associations and telegraph companies in taking matter for publication direct from the wire. By means of it, all the New York dailies are furnished immediately with a clearly-printed copy of important news. The old method of writing out messages as received is gradually being discarded, and even personal telegrams are received in the same manner.

The carriage glides easily forward upon a rod at the back of the machine, supported from the frame by ordinary standards. At the front center, the carriage is supported by a small wheel of hardened steel. A yoke with steel collars connects the carriage to the traveling rack, and thus they move together, one space at a time, and just as fast as the dog passes from one rack to the other. The paper is fed into the machine from behind and passes between two rubber rollers which hold it firmly in place. The smaller of the two, the feed roll, is pressed firmly against the larger by means of feed springs, held in place by set-screws. This insures an even tension at both ends and causes the paper to feed straight. It also admits paper of any thickness and any number of sheets, as the set-screws make the apparatus adjustable. This is one of the most valuable recent improvements. There are two interchangeable rollers or platens, of different diameters, for each machine. These are adjusted, the one for single copy work and the other for manifolding.

The Remington Machine (Fig. 2).—The printing is produced in this machine by type bars rising, so that one set of type strikes at one common printing point, and another set of type strikes at another common printing point, both of which are a trifle off the center of the basket. These bars are hung from the top plate of the machine. The type, however, are arranged in pairs upon the type bars, so that one key answers for two type, requiring, however, an auxiliary shift when any of the upper-case letters are required. This gives a smaller keyboard, there being but 40 keys, which obviously represent 76 characters, as two keys are used for shifting. While this arrangement gives a more compact keyboard, two separate strokes are required to produce any of the upper-case letters. The stroke is made by levers fulcrumed at the back of the machine. This is an easy leverage, requiring a ⅘-in. stroke. The carriage is a 7 × 9¾ in. frame, which rides upon three wheels, two being at the back and one in front. Those at the back are grooved to fit the back rail, while the one in

is that all impressions are made by the oscillating stroke of a type cylinder, Fig. 6. All printing is visible. The cylinder is actuated by means of 28 levers, together with 14 auxiliary levers. There are 28 keys. Two of them represent one character each; the remaining 26 are modified by two shifts, and so the machine produces 80 characters. The principal levers are those of the first class. The auxiliary levers engage in the differential ways on the face of a twirler, situated at the back of the machine. From the upper part of the twirler is a T-shaped arm fitted with teeth, which engage the type-cylinder gear. The type cylinder is held in a slightly inclined position upon a spindle, supported upon a bracket attached to the frame of the machine. In printing, the type cylinder is thrown into a perpendicular position against the face of the platen at a common printing point. By the depression of any key, its levers and auxiliary are set in motion. This moves the twirler, and with it the T-shaped arm which causes the type cylinder to oscillate. At the same time a cam movement, attached to a universal rocker shaft, throws the type cylinder against the platen.

Fig. 6.—Type cylinder.

IV. One-hand Machine.—*The Merritt Typewriter.*—This machine is designed to be operated by one hand. The type stand upright, and are arranged in a movable trough, which is fitted into another so that it can be moved easily from side to side. In the center is the printing point. The type are forced through a slot at this point. Whichever type is directly under the slot is forced against the platen, thus making an impression. An index key is attached to the type trough, and the type are so arranged that each one is brought beneath the slot as the indicator is moved opposite the corresponding character. The letters and characters are arranged in front, so that those most frequently used are nearest each other. This machine has two shifts, one for capital letters, and the other for numbers and other characters. The capitals and characters are arranged on either side of a small letter, so that for one the right shift is required, and for the other the left. Unlike most of the other machines described, the carriage is not moved by a spring, but is thrust forward automatically.

These are the principal machines now on the market. One of the many requisites of a writing machine is its ability to manifold. Those having type bars are especially well adapted for this purpose, as the leverage is much stronger. In a strong, well-made type-bar machine, 10 or 15 copies can be made very readily, and by using a brass platen and double carbon, as many as 40 copies are often taken at once.

On account of the numerous parts necessary to every writing machine, all require more or less attention, and for this reason the simplest mechanism and that least liable to get out of order is preferable.

Valve: see Furnaces, Blast, and articles under Engines.

VALVES.—*The Locke Renewable-disk Valve* is shown in Fig. 1. When the valve is

Fig. 1.—Locke valve.

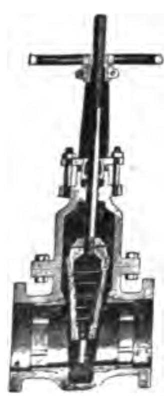


Fig. 2.—Chapman valve.

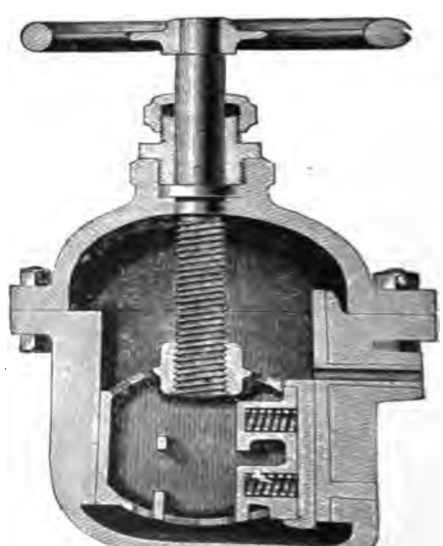


Fig. 3.—Valve with drip.

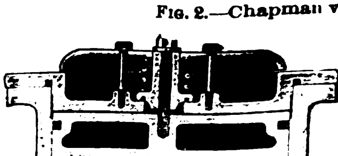


Fig. 4.—Water-relief valve.

int which is determined by the tension of the spring, S, the dia-
by the steam in the chamber, O O, the valve, K, closes, and no more
r the piston, D. The valve, C, is forced to its seat by the initial
off steam from the low-pressure side. This action is repeated as
drops below the required amount. This piston, D, is fitted with a
nts chattering or pounding when the high or low pressure suddenly

k Check Valve is shown in Fig. 9. The ordinary form of check
ng are liable to become leaky by being beaten out by the "water
stroke of the pump. In this valve it is sought to avoid this
t, renewable disk in the form of a truck (as shown in the cut), and
e valve with sufficient bearing surface to prevent the soft packing
ruptured by hammering on the metal seat of the valve. This is
alve seat with arms radiating from the center, thereby supporting
nd at all points from the center to the circumference. A water
ich prevents the contact of the packing with the metal seat; the

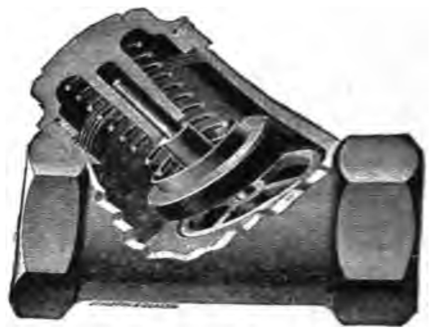
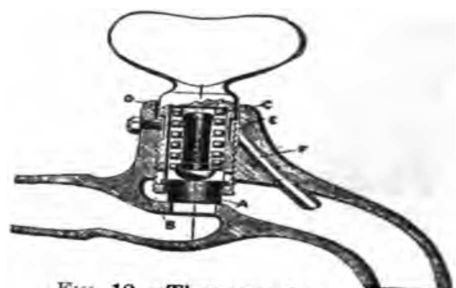


FIG. 9.—Locke's check valve.



lve.

FIG. 10.—Thomson faucet.

r, as the water has to be forced out before the parts can

cet represented in Fig. 10 has recently been devised by Sir
irely of metal. The metal valve, A, on reaching the seat,
rrested and compelled to seat itself hap-hazardly, but con-
idle is turned, receiving meanwhile a gradually increasing
corrosive), centrally applied by the rounded head of the
upon its seat at every opening and closing, and both valve
perfect fit and finish. The manufacturers state that no
e and seat, even after it has been opened and closed as
s' service. The spiral spring has been subjected to com-
ving any loss in power. The cock has been opened and
wing, 540,000 times, or the equivalent of 50 years' use at
test, the valve was still tight. The method adopted to
ng-box is very ingenious. An "eduction tube," F, pro-
ucks out any water which may collect in the chamber
kage around the screw when the valve is opened. This
fective.

M; and REGULATORS.)

iery.

as pillars, bridges, etc., are then fitted and the plates put together. After all the fit- is done, the parts are dismembered, and gilded, and in some instances nickeled. The wheels are punched out in complicated dies, which act so as to perform several operations at one stroke of the press. After punching, they are placed on what is known as a wheel-cutting engine, a number of wheels —generally about 30 or 40 —being put upon an arbor at one time, so that the cutter passes through the whole stack and cuts one tooth in each of the wheels at each stroke of the machine.

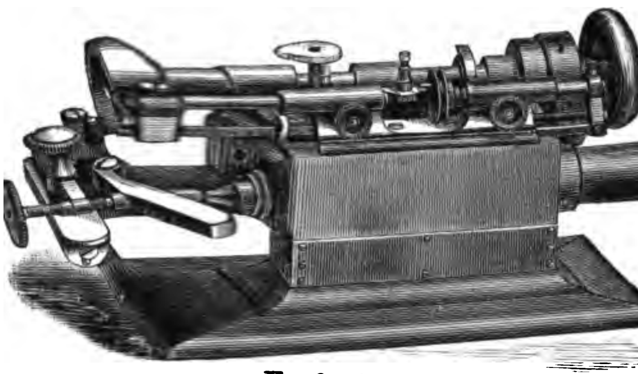


Fig. 2.—Pivot-turning machine.

After the teeth are cut, the wheels are bored, ground, and gilded or nickeled, as the case may be, after which they are ready to be staked or fastened to the pinions. The pinions are cut in suitable lengths from a steel wire by a special cutter or die, made for that purpose, operated by a press similar to that used for the plates and wheels. These wire pinions are then chucked in a lathe, and a point, or center, as it is called, turned on each end, after which they are taken to another lathe, where, by a tool carried in a slide rest, they are turned down rough nearly to size. From this the pinions are set on dead centers in an automatic pivot machine, and turned to the exact size every way ; after that the teeth are cut, and then they are hardened. After being hardened, the teeth are polished by a machine known as a leaf polisher ; then the pivots, staffs, etc., are polished with the "wig-wag," a tool well known to watchmakers and jewelers. All the parts are similarly treated, beginning with the punch and dies in the press, and pass along from one machine to another, until they are ready to be assembled in the finishing or setting up room, and put together to form a timepiece. There are about twenty different mechanical departments in a watch factory, each performing a specific operation, and their products all center in the finishing room.

The Pinion-cutting Engine, manufactured by the Gesswein Machine Co., and shown in Fig. 1, is universally used for cutting the teeth in pinions for watches and clocks. It has a revolving tool head that carries three spindles. One of these drives a saw for cutting away the stock in advance of the other cutters ; the second spindle drives a cutter to rough out the shape of the tooth, and the third spindle operates the finishing cutter, which gives the form to the teeth. The operation of this machine is simple and rapid.

The Automatic Pivot-turning Machine shown in Fig. 2, a very ingenious piece of mechanism, also made by the Gesswein Machine Co., is for turning the staffs and pivots on all pinions, pallet arbor, etc. The wire is pointed and rough turned in a No. 2½ lathe ; it is then placed on dead centers in this machine and turned very accurately to a length from shoulder to shoulder, and also in diameter. The turned staffs and pivots are then hardened, and after hardening, are ground and finished on the "wig-wag" machine.

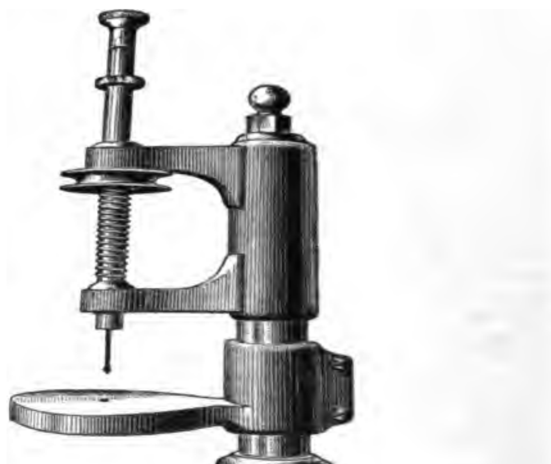
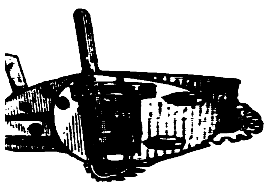


Fig. 3.—Upright drill.

The form of upright drill which is mostly called into use in the manufacture of the several parts of watches and clocks is that shown in Fig. 3. The spring action of the drill stock makes it specially serviceable for this fine work, and in the drilling of plates, bridges, etc. Fig. 4 shows a screw-cutting machine of the Gesswein Co.'s make, largely used in watch manufacture. A wire is fed forward through the chuck, which projects between two movable cutting heads, and the tail stock has a horizontal screwed rod which acts as an adjustable stop or the end of the wire, in determining the length of screw to be cut. One of the slide rests or heads carries the thread-cutting tool, and the other, the cutting-off tool. This figure also shows a detached view of a tail stock for the same machine, with multiple stop

akers to whom the attachments are sold. Fig. 7 is a view of this attachment look-ts underside, and Fig. 8 represents a Howard watch embodying the same. Upon iding stem, in addition to the winding pinion which meshes with the crown wheel. ed (upon a square portion) a sliding double-clutch wheel, acted upon by a spring to it normally up to engagement with a clutch on the lower side of the above winding. This is the normal position, and the one occupied by the parts for winding the. The movement of the setting lever causes the spring to act in the reverse direction, thus throwing the sliding clutch downward so that the lower teeth of the latter will mesh with one of two intermediate setting wheels, the latter of which meshes with the first and engages also with the usual minute wheel, which meshes with the ordinary cannon pinion, on the end of which is mounted the minute hand. Over the cannon pinion is placed the hour ıeel, carrying the hour hand as usual. The parts ing in this position, the hands can be moved.



G. 7.—Attachment.

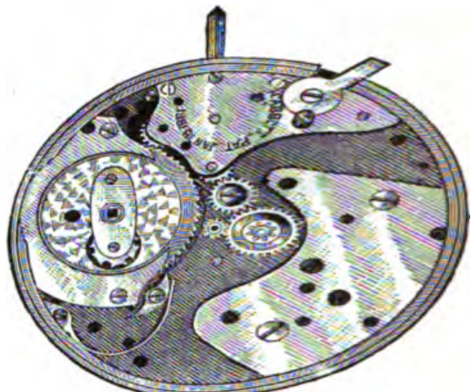


FIG. 8.—Howard watch.

Marking Dials.—An ingenious invention of Mr. ›bott is the new method of marking the numerals, visions, letters, and ornamentations upon watch ıls, which is controlled and largely used by the gin Watch Co. The process does away with all inting or marking by hand upon the dial itself. ıe blank dial plate is made up as usual of a copper se coated with enamel, and the design for the face first engraved upon a steel or copper plate. This is coated with the ordinary vitrifiable gment, and allowed to dry; then the surface of the plate is brushed off, leaving the filling act. A layer or coating composed of a preparation of collodion is now laid upon the entire rface of the plate, and this permeates and goes down through the filling of pigment, and actically covers the underside of the pattern. Evaporation causes the formation of a m on both sides, with the pigment lying between, and by this means the complete pattern tended for the dial plate may be cleared from the engraved matrix, preserving even the ery finest lines intact. This is accomplished by immersing the engraved plate in a bath acid and alkali. The film floats off, and, being somewhat soft, it readily sticks to the ial plate upon which it is now placed, and after baking as is usual with enameled plates, it found that the collodion film has been burned off, leaving the pigment (the whole pattern) permanently incorporated with the dial plate.

The Waterbury Watch has probably taken first place in the category of cheap timepieces. It is extremely simple, being made up of less than one-half of the number of parts usual in a watch, and these are so arranged as to be easily cleaned or repaired. The great differences between this movement and others are that it has a long, thin mainspring (nearly four times the length of an ordinary watch spring), and that the entire movement revolves in the case once every hour, and thus regulates or adjusts itself to varying positions. The use of the long mainspring is consequent upon the reduction in number of parts; there is no barrel used, and two wheels and their pinions are also dispensed with in the train, which places the power direct upon the escapement. The latter is of the duplex pattern, and is very light running; it has only two pieces, the balance and escape-wheel. There is a stop work to prevent damage from verwinding at the stem, and all the parts are made interchangeable.

FIG. 9.—Waterbury watch.

FIG. 10.—Regulator.

The case of this "long-wind" watch is stamped out in only two pieces, and nickeled. To et the hands, it is necessary to remove the bezel entirely, and use a point, or the finger, in his operation, as well as in adjusting the regulator, which is approached from the front. ig. 9 is a view of this watch with the bezel off, and Fig. 10 represents the regulator and art of the movement.

The Waterbury Watch Co. is also making cheap "short-wind" watches, with cases nickel, coin silver, oxidized silver, and gold filled, and of several sizes and various signs. Fig. 11 shows the working parts of this "short-wind" watch, the balance wheel,

the independent bridge, the tempered hairspring, back ratchet, etc., as well as the windi parts. The "wind" is simple, being composed of only five pieces. Both the pillar and t plates are made double, which arrangement holds the winding work and jewels in positio and takes the place of the ordinary bridges, screws, etc.

FIG. 11.—Waterbury "short wind" wat

RECENT IMPROVEMENTS IN WATCH-MAKING.—The Waltham Watch Co. introduced a novel improvement in the movements of their make a few years ago, which has helped to offset any damage done to the train following the breaking of the mainspring. The center pinion is removably fixed to the center staff; the pinion has its axial hole screw-threaded to correspond with a similar thread upon the staff, the direction of thread being such that the strain of the mainspring, acting through the teeth of the barrel upon the pinion, will force it against a shoulder formed for the purpose on the staff, making it practically a single piece; but should the mainspring break, the violent recoil of the broken spring would simply serve to unscrew the pinion from the staff without harm to either, instead of having the effect of breaking the teeth of the barrel and pinion.

The Non-Magnetic Watch.—The Waltham Watch Co. has recently perfected and put on the market the non-magnetic watch, the result of expensive experiments since 1887; such watches being especially valuable to electricians and other persons liable to go near dynamos, electric car motors, and the like. This achievement in modern horology has been accomplished by substituting for steel i the balance, roller, hairspring, and pallet and fork (which together constitute th of the watch designated as escapement), metals or alloys which are non-magnetic, yet possess the properties of elasticity and expansion such relative proporti able them to compensate for the varying conditions of heat and cold.

How difficult a problem this has been to solve may be imagined when it i that no single known metal possesses all the qualities required. And, further, the different portions of the escapement requires to be constructed of metal h characteristics which shall fit it for the peculiar duty of that part, and whic demanded by some other part.

There are, however, two requisite properties common to all the parts: f ductility to be capable of being brought into the required form; second, no to magnetic influence. The function of the fork demands a metal able to w the hairspring must possess elasticity in a high degree, and yet must be c fixed or "set" in proper spiral form.

The duties of the balance require that its body be made capable of a expansion under the influence of heat, but it must not be too expansive lamina of the rim must have a very high ratio of expansion, without undu comb

CLOCKS.—*Recent Improvements.*—Clocks have recently been of record, by whi stamps, for use in banks and in city and court offices papers filed are not only marked with the day, month, and year, but the of the day the papers were filed.

Outside of the automatic novelties known as the swing clock and the improvements in clocks have been limited to various different construc Among these various improvements may be mentioned the Blakesley clo in lieu of the usual pallet a worm engaging with the escape wheel, the w an arm so connected with the pendulum as to impart a rotary movement

The late Henry J. Davies, so long connected with the Ansonia Cloc improvements in that particular class of goods put on the market by among which may be mentioned a construction in which the main whee attached to it the inner end of the mainspring, which is arranged in with the center arbor of the clock. The clock case has a loose back or attached to it a rigid ratchet adapted to rotate freely around the main winding up the clock, and having one or more clicks to prevent the b mainspring. The main arbor also was tubular, and through this wheel arbor, having a key at its end for the adjustment of the hands ext clock.

Another form of the escapement is that invented by Edmond Kuhn,

pinion cap having four arms, which, upon rotating, successively strike the escapement wheel to rotate it as usual.

Another novelty is a clock made by the New Haven Clock Co., which employs two pendulums suspended on trunnions vertically in line, and connected together by pinions which transmit a reverse oscillating movement from one to the other, one of the pendulums being connected with the anchor of the escape movement.

A different form of escapement lever, the invention of Mr. Bannatyre, is made by the Waterbury Clock Co., which has an impulse fork at one end, a bank fork at the other end, and with a laterally projecting ear upon each side between the forks, said ears being formed integral with the lever. The lever has two pallet pins, made wedge-shape in cross section, and the ears are constructed with holes of corresponding wedge-shape, into which said pins are forced.

A novel method of making hairsprings for balances was invented by Mr. Logan, of Waltham, Mass., which consists in simultaneously coiling two parts of a piece of wire around a suitable snail or former, beginning at a ligature which constitutes the central portion of said piece, thereby converting the said two parts of the single piece of wire into two coils, which are integral with each other, their inner ends being connected by the ligature. These two coils are then hardened, in the usual manner, while their ends are yet connected, and are finally separated to complete the springs by severing the ligature. This is said to be a very efficient and cheap mode of making hairsprings.

A further improvement in an escapement for timepieces was made by Mr. Hansen, in which the balance wheel has a spring for imparting motion to it in one direction, and a spring-actuated lever for imparting motion to it in the other direction, the lever being provided at one end with a pallet for engagement by the escape wheel, and with a hook at its other end, and a locking pin for effecting the disengagement of the hook and pin, which thus permits the passage of a tooth of the escape wheel and allows an impulse to the balance wheel.

A clock-winding mechanism, which permits the train to continue its movement while the mainspring is being wound, consists in winding the spring from the outside through the barrel instead of through the arbor.

One of the smallest lantern pinions probably made is that now used in some of the cheaper forms of clocks, in which the staff has two collets, one of which is constructed with a circular series of perforations and the other with a series of corresponding seats. A series of leaves extend through these perforations of the one collet into the corresponding seats in the other collet, and a cap is mounted on the staff so as to bear directly against the outer face of the perforated collet, which thus prevents the leaves from becoming displaced.

In a clock called the "Independent Electric Clock," in which the electrical movement is entirely independent of the ordinary pendulum movement, there is combined with the escapement a spring for turning the escape wheel, a ratchet and pawl for winding up the spring at intervals, the usual hands, and an electro-magnet for actuating the pawl of the winding spring and for moving the minute wheel step by step.

Another very important improvement is in arranging a single spring to drive the train as well as to operate the striking mechanism, which is made by the Waterbury Clock Co., and in this clock it is impossible to disarrange the striking mechanism so as to make it strike falsely. The clock may be turned to any extent backward, and when moved forward will strike correctly the half hours as well as the hours.

WATER METERS. *The Thomson Water Meter* is shown in Fig. 1. The displacing or measuring member consists of a flat disk, having a ball-and-socket bearing, and is adapted to oscillate in a chamber, comprised of two sections joined together, in which each of the inside faces approximates the frustum of a cone, the exterior confining wall assuming the form of a circular zone. The disk has a single slot projecting radially from the ball, which embraces a fixed metallic diaphragm, set within and crosswise of one side of the chamber, the disk being thus prevented from rotating; but when it is caused to oscillate in contact with the cone frustums, the chamber, by these means, is divided into sub-compartments, or measuring spaces. Now, if the ports of ingress and egress are properly disposed on opposite sides of the diaphragm, the disk will act as its own valve. The course of the flow through the meter is as follows: Entering the compartment, formed by the upper and lower caps, the current passes on all sides of the chamber, to and through the inlet port; thence through the measuring chamber (causing the oscillation of the disk), then through the outlet port, to the outlet spud and the pipe. At all sections in this path, from the inlet to the outlet, the velocity of flow is much less than that through the pipe. The oscillation of the disk produces in its central axis, at a right angle to the plane of the disk, circular motion. Advantage is taken of this to control its proper relative action in respect to the cone frustums, by mounting a conical roller upon a spindle fixed in

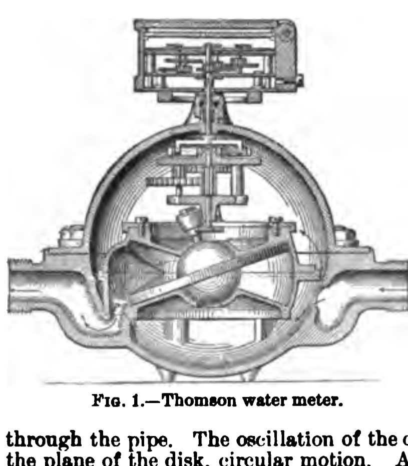
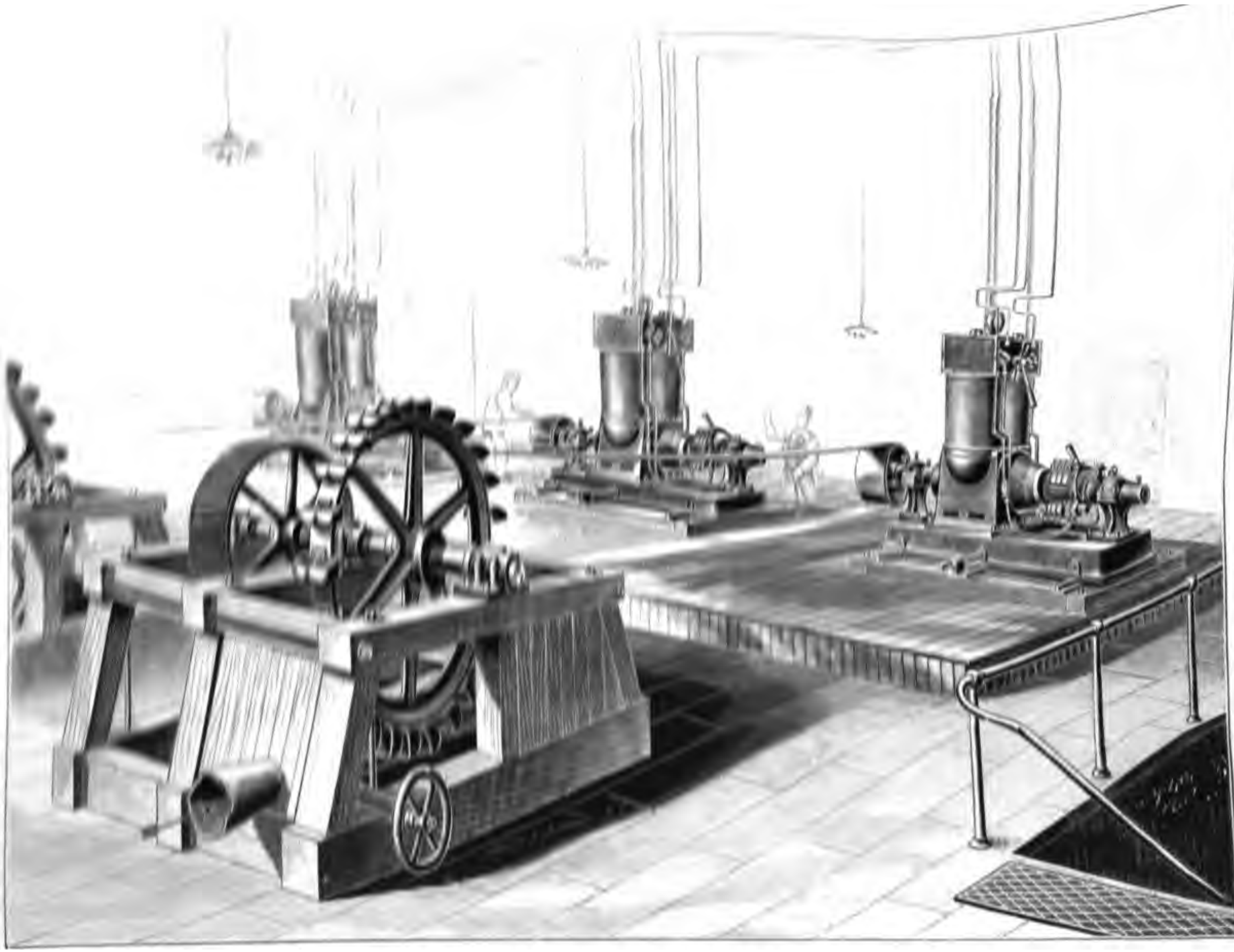


FIG. 1.—Thomson water meter.



DRIVING DYNAMOS BY THE PELTON WATER-WHEEL.

the ball. This roller impinges upon and rolls around the fixed conical stud or hub, formed the inner side of the gear frame. The roller turns upon a conical sleeve which is screw upon the disk spindle; the object of this construction being to avoid any tendency to produ end-thrust, consequent upon the angular thrust of the spindle, disk and also to provide mea whereby to obtain the proper relative adjustment between the disk and the cone frustu The accidental displacement of the adjusting sleeve is prevented by inserting a pin thro its shoulder and also the body of the spindle, which is then bent, each end at a right an to the other, to lock it in place. This circular motion of the spindle is also utilized to d the registering mechanism by means of an arm secured to the primary pinion of the tra the arm impinging upon and being driven by the lower extension of the roller. The tr of the motion of the disk is to thrust the edge of the slot constantly against the outlet of the diaphragm.

The diaphragm is made of hard rolled metal, which is shaped very accurately, an rigidly secured between the two sections of the disk chamber. The internal gearing w connects the disk to the stuffing-box spindle is mounted between two separate plates sec together by pillars, as in clocks, and, in the smaller sizes, the whole as a single structu secured by screws directly to the disk chamber. The gearing stands in the upper porti the compartment, and is thus out of the direct path of the current.

The Venturi Meter, made by the Builder's Iron Foundry, Providence, R. I., is show Fig. 2. It is the invention of Mr. Clemens Herschel, and was first described by him a December, 1887, meeting of the American Society of Civil Engineers. Its action is fou on the well-known property of a Venturi tube to exercise a sucking action through holes bored into its narrowest section. The construction of the meter, as shown by the accompanying cut, is merely a contraction of the main pipe, to which two ordinary pressure gauges are connected—one at any convenient point before contraction of pipe begins; the other at the smallest section. When any flow in the pipe occurs the pressure on throat gauge will fall, if the flow becomes sufficiently rapid, all pressure at the throat may disappear and a vacuum obtain. The other gauge, however, will continue to indicate the pressure due to the supply. By mathematical calculation and exp confirmation, a formula, based on the different pressures on the gauges, has been which accurately indicates the velocity of flow through the throat of the meter. nary self-recording differential gauge may be used to obtain a diagram of these v pressure, from which both the velocity at any given time, and the total quanti any interval, may be readily determined.

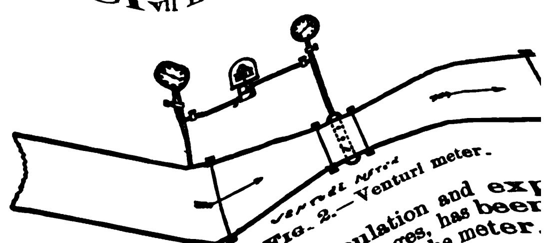


Fig. 2.—Venturi meter.

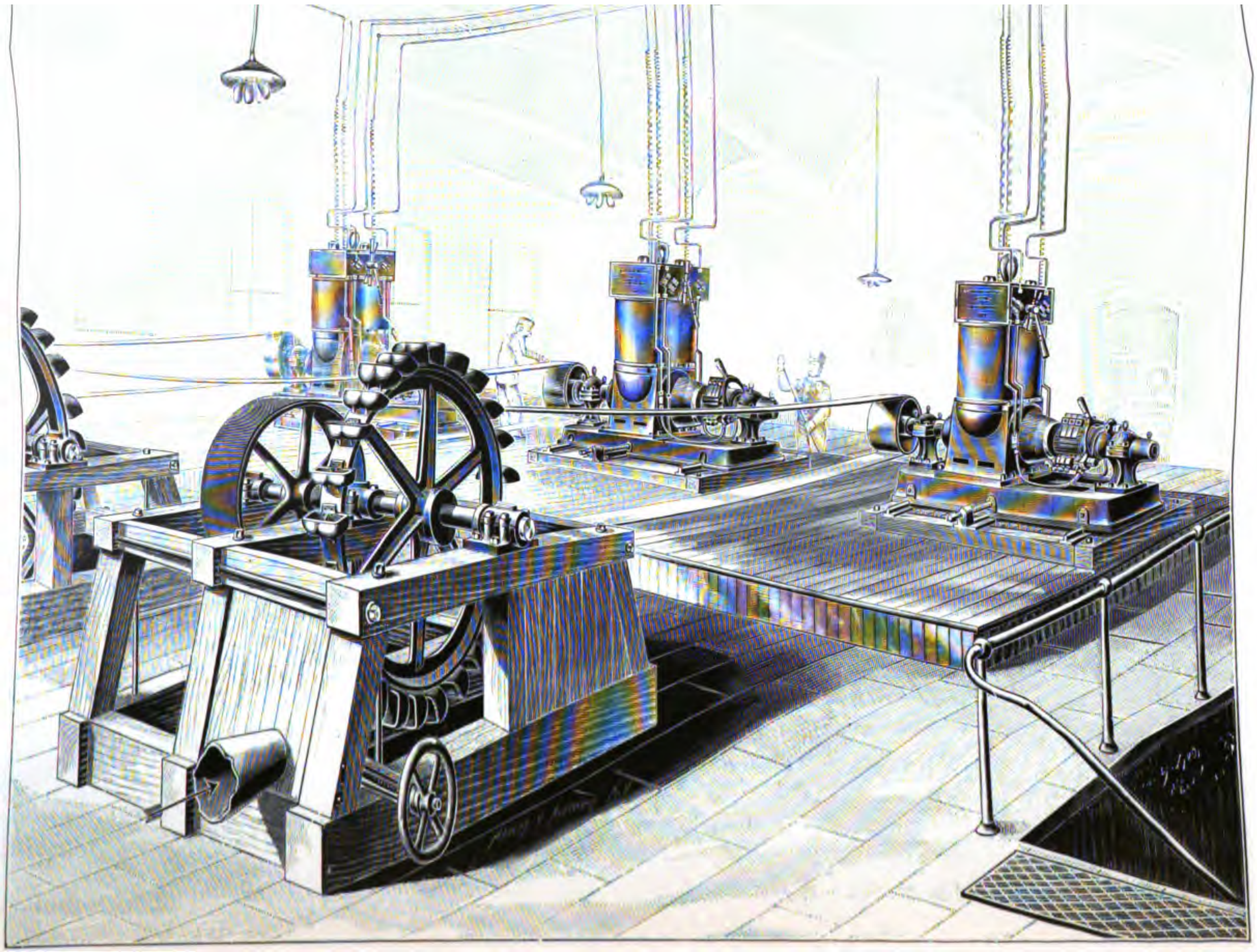
Water Tower: see Fire Appliances.

WATER WHEELS. The old "outward flow" and "inward flow" and "inward flow," as outlined practically given place to the "inward and downward flow," wheel (see Appleton's Cyclopedia of Applied Mechanics); but the change f to those of less diameter, with deeper buckets, of longer curve, has been ve resulted in higher efficiency, as well as greater economy in first cost. The parison illustrates this point.

Wheel.	Diameter.	Revolutions per minute.	Cubic fe[et] per m[inute]
Boyden	36 in.	161	[illegible]
Swain	30	197	[illegible]
Risdon, "D. C."	30	210	[illegible]
Victor	30	183	[illegible]
Hercules	30	174	[illegible]

The Risdon Wheel.—The foregoing figures are taken from the pub are probably close the wheels, and discrepancy in the veloc there is a discharge has been pr portion of the being closed down the buckets so curved as to central core, and as shown in Fig. from the centre "double capacity" whee C." or This form of bucket appears to ta centrifugal motion given to the self, and which in the case of the wa charge was directly opposed to the Another cause of the displaceme discharge" wheel was the very "part gate," or when the water po edged cylinder, or register, gate.

Fig. 1.—The Risdon Wheel.



DRIVING DYNAMOS BY THE PELTON WATER-WHEEL.

the ball. This roller impinges upon and rolls around the fixed conical st the inner side of the gear frame. The roller turns upon a conical sle upon the disk spindle; the object of this construction being to avoid any end-thrust, consequent upon the angular thrust of the spindle, disk an whereby to obtain the proper relative adjustment between the disk and The accidental displacement of the adjusting sleeve is prevented by its its shoulder and also the body of the spindle, which is then bent, each to the other, to lock it in place. This circular motion of the spindle is the registering mechanism by means of an arm secured to the primary the arm impinging upon and being driven by the lower extension of t of the motion of the disk is to thrust the edge of the slot constantly of the diaphragm.

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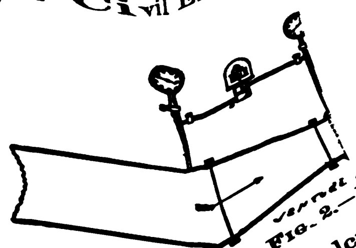


FIG. 2.

Water Tower: see Fire Appliances.

WATER WHEELS. The old "outward flow" and "inwa practically given place to the "inward and downward flow," as wheel (see APPLETON'S CYCLOPEDIA OF APPLIED MECHANICS); but th to those of less diameter, with deeper buckets, of longer curve, h resulted in higher efficiency, as well as greater economy in first parison illustrates this point.

Wheel.	Diameter.		Revolutions per minute
Boyden	36 in.		161
Swain	30		197
Risdon, "D. C."	30		210
Victor	30		188
Hercules	30		174

The Risdon Wheel.—The foregoing figures are taken fro the wheels, and are prob there is a discrepancy in portion of the discharge b the buckets being close central core, and so curv from the centre, as show C." or "double capacit This form of bucket app centrifugal motion given self, and which in the cas charge was directly oppos Another cause of the d discharge" wheel was the "part gate," or when the edged cylinder, or regist

FIG. 1.—The Risdon Wheel.

.lly has enabled them to be so formed as to deliver the water in an unbroken volume, tages which contract the flow, instead of cutting it partially off. us, while the Boyden dropped from an efficiency of 79 per cent. at full gate to 44 nt. with half water; and the Houston from 81 per cent. to 23 per cent.; the "Risdon" from 87 per cent. to 70 per cent., and the "Hercules" from 87 per cent. to 74 per , in Professor Thurston's best test. The Risdon wheels at the Jefferson mill of the skeag Manufacturing Co., Manchester, N. H., consist of two pairs of 43-in., and one of 36-in. "D. C.," as shown in cut of bucket, and are all mounted on a 9-in. steel

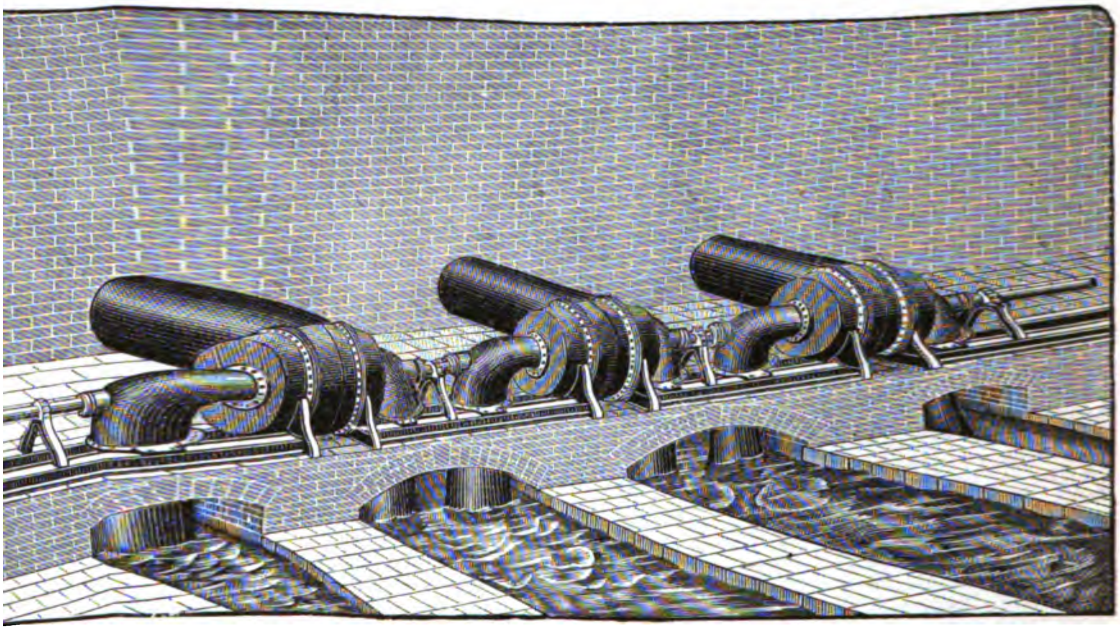


FIG. 2.—The Risdon wheels at the Jefferson mill.

haft, with couplings between the 43-in. and the 36-in., so that the latter, which draw water rom a lower level, can be disconnected if desired. The head on the 43-in. wheels is 49 ft.; hat on the 36-in. ones is 28 ft., giving them the same circumferential velocity, at 225 revolutions per minute.

Fig. 2 illustrates one of the most complete systems of horizontal-shaft turbines yet introuced, *viz.*: that furnished by the Risdon Co. (previously described) for the Jefferson mill f the Amoskeag Co., at Manchester, N. H. It consists, as shown, of 6 wheels, in 3 pairs, on ne shaft; one pair, under a lower head, being of smaller diameter, so as to have the same ırface velocity, or 62 per cent. of that due to the head.

These wheels themselves are all solid bronze castings, but the cases and draft tubes are st-iron, and the feeder pipes boiler plate. Six small ıeels were here adopted, in place of three large ones, as st suggested, to obtain higher velocity of shaft, smaller iving pulleys as a consequence, and the ability to use as ·ge a proportion of the very variable quantity of water the best advantage, or as near "full gate" as possible.

The Collins Wheel.—A form of gate, similar in effect that used on the Fontaine turbine, exhibited by Messrs. ·oment, Meurice & Co., in London, in 1851, and which ay be called a "plunger gate," is used on the Collins downward flow" turbine shown in Fig. 3. This form of ıte raised the efficiency of the Collins wheel to 85 per cent. full gate, and 66 per cent. with 0.565 water, which Prossor Thurston says is the best performance of a Jonval rbine on record.

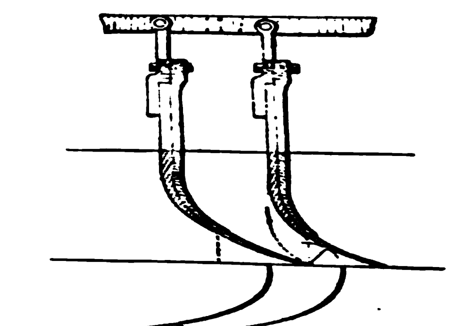
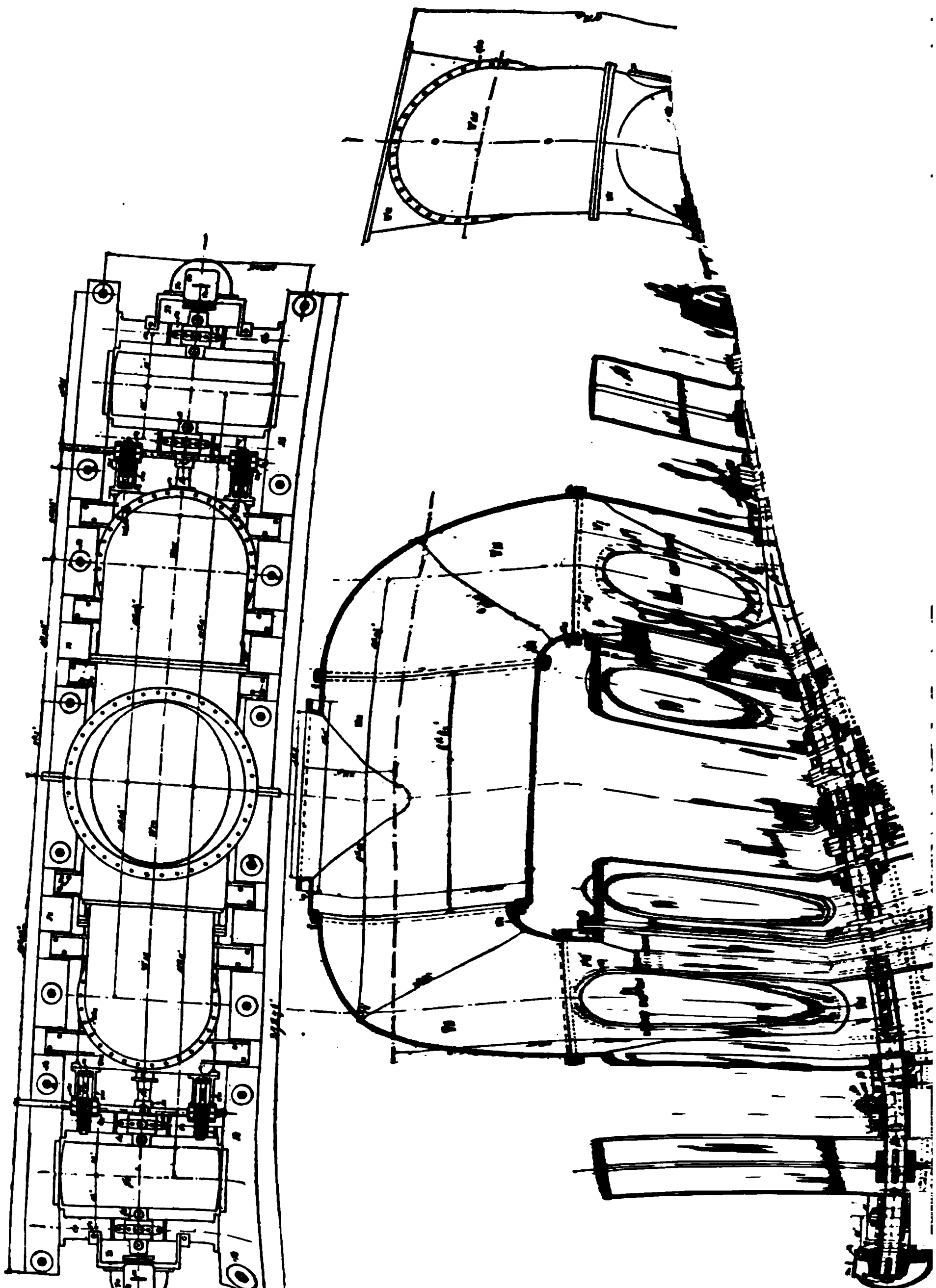


FIG. 3.—The Collins wheel.

Another well-known form of the Jonval turbine is the Jeyelin," built by Messrs. R. D. Wood & Co., of Philadelia. One of these wheels, as tested by the writer, at the ıtennial Exposition in 1876, gave over 84 per cent. net ›ct, and practically the same result was obtained from a 7-ft. wheel of the same style

at the John P. King mill, at Augusta, Ga., 475 hor
last test. All this type of Jonval wheels give high re
defective at "part gate."



This name of "Jonval" is applied to wheels set with a "
on the fall, intermediate from the bottom to 28 or 30 ft. abo
The draft tube was patented in the United States by Z
Licking, O., in 1840. It has proved of great value, by enabl
zontal shafts.

Figs. 4 and 5 illustrate the construction of the Geyelin turbine constructed for Cornell iversity, by Messrs. R. D. Wood & Co. The turbines are 34 in. in diameter, and are culated to produce 175 horse-power at 40 ft. head. Their speed is 253 revolutions per

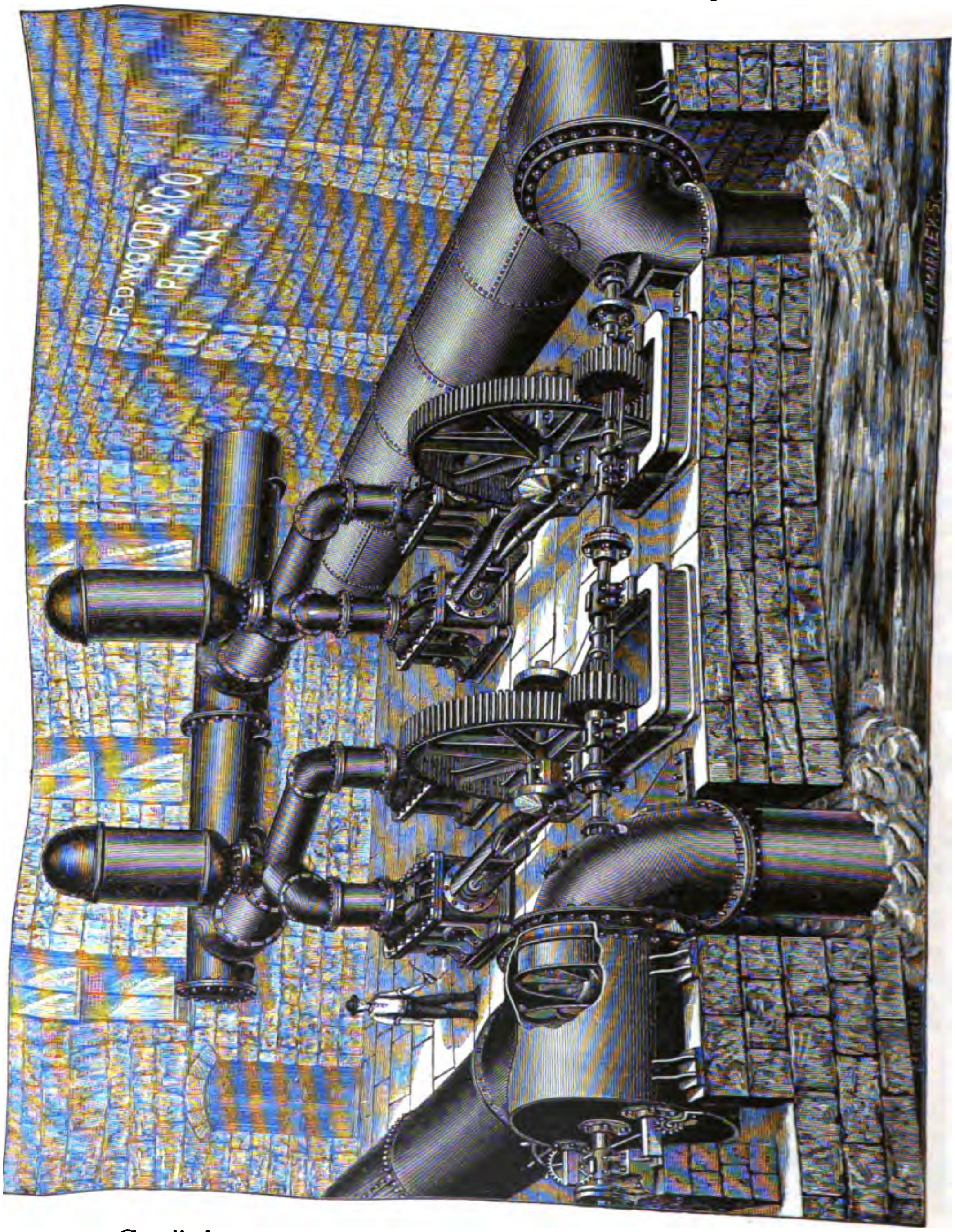


Fig. 5.—Geyelin turbines at Cornell University.

ite. Mr. Geyelin has devised a novel and effective form of glass suspension stop, which ustrated in cross section in Fig. 6. The revolving disk, *A*, which supports the wheel, on the glass disks, *B B*.

The Hunt Wheel has since been improved by the additi bringing the half-water effect up to 66 per cent. These "a appearing between the chutes. The next great step in turbi them on horizontal shafts, and, when practicable, in pairs, so as to thrust against each other, and neutralize step friction.

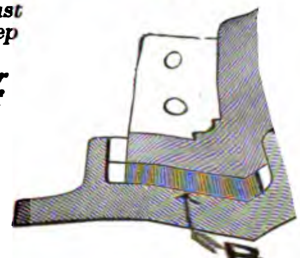


FIG. 6.—

Glynn, in his *Treatise on Water Power* (John Weale, 1853), speaks of this method as being advised by Professor Wedding, of Berlin, for the Archimedian scroll wheels, to save step and gear friction. About 1861, the late John C. Hoadley put in a scroll wheel of this sort, in Manchester, N. H., and the writer followed it within two years later by seven small iron turbines, set in iron pipes, singly, and in 1876 the Swain Turbine Co. put in a pair of wheels i and the plan is now adopted by all prominent turbine buil

Fig. 8 shows the external case of a pair of Hunt wh central draft tube. This method of setting saves not only the loss of power by their friction, commonly estimated at of a Hunt wheel, at the Holyoke testing flume (on vertical respectively ·8006, and ·8048 per cent. effect, and the same the mill at Lowell, was tested by Mr. Francis, givin

The Humphrey curve of crown and water to the wheel also in the natural "vena contracta," down to the bottom outward delivery, as point claimed is th guides or chutes, th water reaches the obstruction to the ter, such as the discharge of leaves that its total water wheel, and that veloc thus doing away the result from reacti the best results, fro he has tested, wh at the point of c 52 per cent. of th head," or to the vein." A very la diameter, using under 12½ ft. fall in 1888, gave ov per cent. net eff with half water,

The Victor Bierce Co., of effective form o deep openings, ing downward wheel separately Reliable tests

FIG. 7.—The Hunt wheel.

ciency of from 80 to 89 per cent. at full gate, the high small wheel, 15 in. diameter, this being the usual results efficiency at one-half water, which must be distinguished cent. with the register gate, but a cylinder gate with show the power and effect of one of these small wheels, Victor, made a few years since at the Holyoke testing fl ments to determine the friction of gearing. The wheel previously, by James Emerson, giving a net effect of 92 ·58 348·5 revolutions per minute, and these tests show a loss

Other tests, which it is unnecessary to tabulate here, sh and contact of the gears, this loss at times might be full

In these tests, the velocity of the external surface o

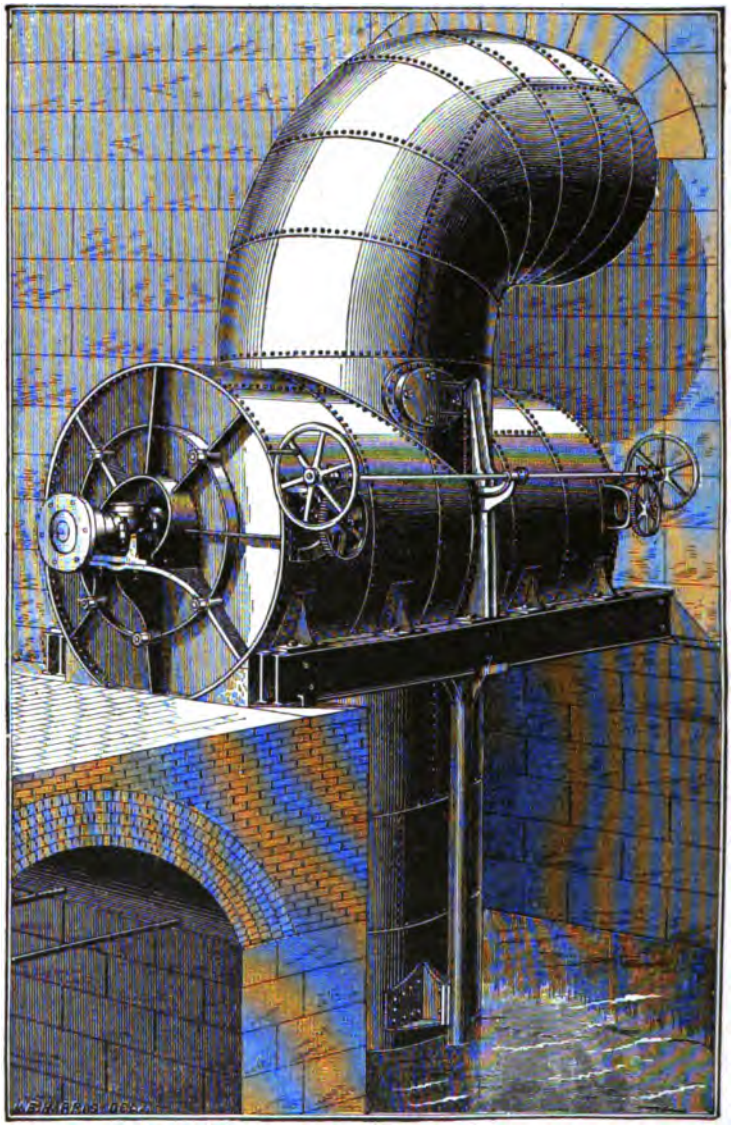


FIG. 8.—Hunt wheel case.

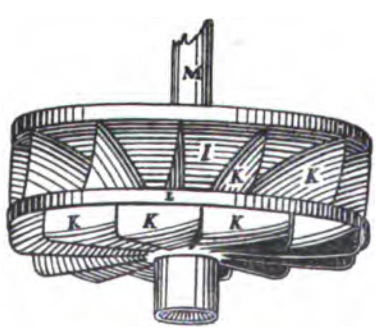


FIG. 9.—Humphrey wheel.

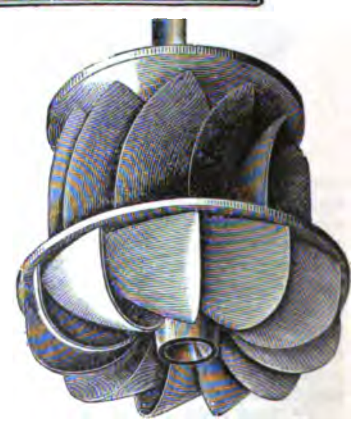
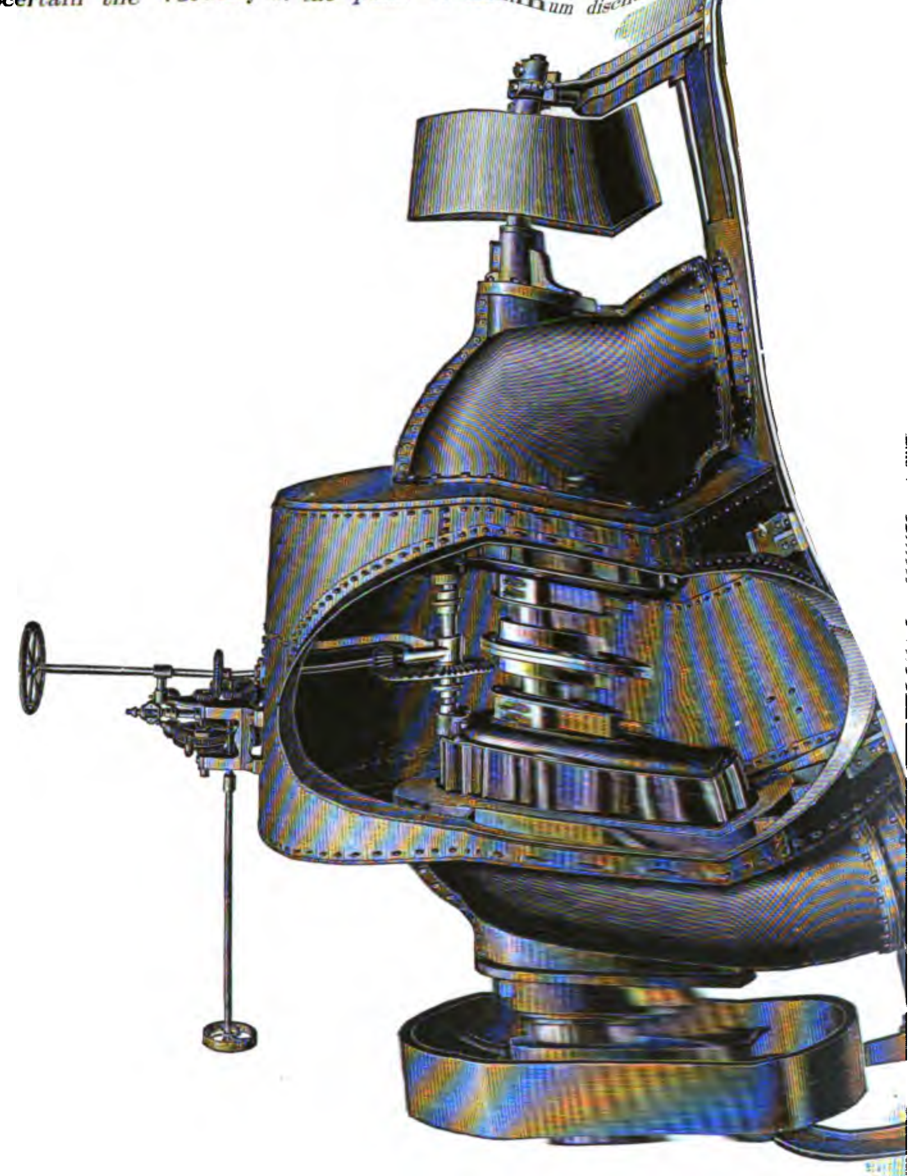


FIG. 10.—Victor wheel.

cent. of the theoretical velocity of the water. From the shape of the ... but to ascertain the velocity at the point of maximum discharge, ...



been *about* 58 per cent. of the theoretical velocity. ... Emerson's with half-water. Fig. 11 shows the Victor wheel on ... horizontal ... after passi... n jack sha... 34·64 cub. ...

Tests of a 15-in. Victor Wheel, taken on jack shaft ... gears, viz.: crown gear on wheel shaft, 46 teeth; gear ... friction pulley; 6 ft. weir. Constant leak deducted ...

No. test	Gate open full.	Head in feet.	Weir in feet.	Water in cub. ft. per minute.	Horse-power, water.	Pounds in scale.	Revolution wheel.
1		18·05	0·962	960·21	32·72	150	367·
2		18·04	·965	966·94	32·89	160	342·5
3		18·05	·970	973·59	33·19	165	330·
4		18·04	·972	976·94	33·29	170	315·
5		18·03	·971	975·26	33·21	[illegible]	286·

he Hercules Wheel.—This wheel in case is very similar in external appearance to the or, but has a cylinder gate, rising to admit the water, and the buckets are provided with rior flanges, which tend to confine the water at partial gate, and keep it from spreading 'aste over the surface of the wheel. In this wheel, the buckets are cast singly. The es of the separate buckets fit together and form the base of the wheel, and are bolted to iron or steel ring which surrounds them. This wheel is so constructed as to give the hest efficiency at three-fourth gate, or seven-eighth water, and should be run so in pracal use, leaving the other quarter gate to be opened in case of high water, when the waste n be afforded.

Numerous tests in the writer's possession show from 80 to 84 per cent. efficiency at ven-eighth water, and when it is considered that the apparent loss of 15 per cent. inudes all the power required to overcome the *vis inertia* of the wheel, the step and bearing iction, and such small amount of *slip* of water as may be actually wasted, it will be seen hat not much more than 85 per cent. should be expected from a wheel in practical use.

The accompanying record of tests of a 33-in. Hercules wheel, made a few years since at he Holyoke testing flume, is in some respects very valuable. It does not show quite so high percentage of effect as some of these wheels have since done, but it shows a high average per ent. down to nearly half water, or less than half gate, with the highest results at about even-eighth water, leaving the other 4 in. of gate, equal to 10 horse-power, to be used in ase of back water, from floods in the river. It is the record of the last series of three days' uccessive tests, which varied but a small fraction of 1 per cent. in their results.

The water was measured over a 12-ft. weir, and a uniform "gate leak" of 56·28 cub. ft. er minute is in all cases deducted from the quantity of water.

The circle of the friction pulley was 20 ft., which, multiplied by the weight, and revoluions per minute, gives the horse-power. It will be seen that the highest results obtained rom this wheel were at a velocity of 152 revolutions per minute. This gives a velocity of xternal circumference, at entrance of water, of 66 per cent. of the theoretical velocity under he head, and as the buckets are so formed as to discharge the water in as centrifugal a lirection as possible, the velocity at point of maximum discharge appears, like that of the Victor, to be about 58 per cent. of theoretical. As the water enters this wheel through conerging chutes, it probably reaches the wheel at a higher velocity than the 66 per cent. noted y the revolutions.

Table showing record of tests of a Hercules wheel.

No. test.	Gate opening.	Head on wheel in feet	Head on weir in feet	Cub. ft. water per min., less waste.	Gross horse-power water.	Pounds in scale.	Revs per min., wheel.	Horse-power wheel.	Net effect per cent.
1	Full gate.	17·28	1·615	4,732·11	154·45	1,300	155·33	122·33	·7924
2	22 turns shaft.	17·26	1·610	4,710·81	153·54	1,325	152·5	122·45	·7975
3	"	"	1·615	4,732·11	154·28	1,350	143·25	122·11	·7915
4	"	"	"	"	"	"	150·5	123·14	·7982
5	"	"	1·616	4,736·48	154·42	1,375	146·5	122·08	·7906
6	Part gate. 20 turns.	17·35	1·566	4,519·69	148·14	1,300	150·	118·18	·8000
7	" " " "	"	1·565	4,515·89	148·	1,250	157·	118·94	·8036
8	" " 18 "	17·45	1·502	4,246·77	139·98	"	147·5	111·74	·7983
9	" " " "	17·42	1·494	4,213·02	138·62	1,200	154·5	112·36	·8107
10	" " " "	17·43	1·495	4,217·24	138·85	1,225	152·	112·85	·8127
11	" " 16 "	17·54	1·417	3,892·45	128·96	1,150	149·67	104·31	·8042
12	" " " "	"	1·420	3,904·79	129·94	1,125	152·5	103·98	·8000
13	" " 15 "	17·59	1·375	3,720·09	123·68	1,050	153·5	97·68	·7901
14	" " 14 "	17·58	1·330	3,539·76	117·55	"	146·	92·91	·7904
15	" " " "	17·60	1·326	3,523·8	117·15	1,000	151·	91·52	·7812
16	" " " "	17·62	1·318	3,491·95	116·22	975	154·	91·	·7830
17	" " 13 "	17·28	1·238	3,294·82	107·54	950	145·	83·48	·7763
18	" " " "	17·31	1·262	3,271·39	106·96	900	150·5	82·09	·7675
19	" " 12 "	17·25	1·210	3,070·61	100·05	850	148·	76·24	·7620
20	" " " "	"	1·206	3,055·34	99·55	825	151·	75·62	·7600
21	" " 11 "	17·40	1·153	2,855·12	93·84	750	147·5	67·10	·7157
22	" " " "	17·01	1·146	2,829·	90·89	725	151·	66·66	·7334
23	" " 10 "	17·20	1·084	2,600·84	84·50	650	153·	60·27	·7132
24	" " 9½ "	17·34	1·050	2,478·28	81·17	600	153·5	55·82	·6877
25	" " " "	17·37	1·042	2,449·7	80·37	550	161·	53·67	·6677
23	" " 9 "	17·39	1·040	2,442·68	80·33	600	150·5	54·73	·6821

The Leffel Wheel, represented in Fig. 12, is of the horizontal-shaft type, and embodies the atest improvements in the double-discharge construction. The water is divided equally at he center, and passes laterally and parallel with the shaft in opposite directions, discharging lownwards on each side of the wheel through curved pipes. This casing is made as narrow hrough the central portion as possible, for the purpose of obtaining the shortest distance etween the journals, bringing them as near to the wheel as the discharge space will admit. These wheels may be used for various purposes, particularly where a large amount of power transmitted from a main horizontal line of shafting, and from the pulleys of which direct onnection can be made to one or more pulleys on the horizontal water-wheel shaft. Many plications of double-discharge wheels have been made to electric lighting, electric power, d other uses, directly from pulleys on the water-wheel shaft to the pulleys on the dynamo, e saw arbor, or the pumping machinery.

A novel form of the Leffel wheel is known as the t
regularly built James Leffel wheels, either standard
drical wrought-iron casing, with cast-iron heads, th
durably built. Both wheels discharge the water towa

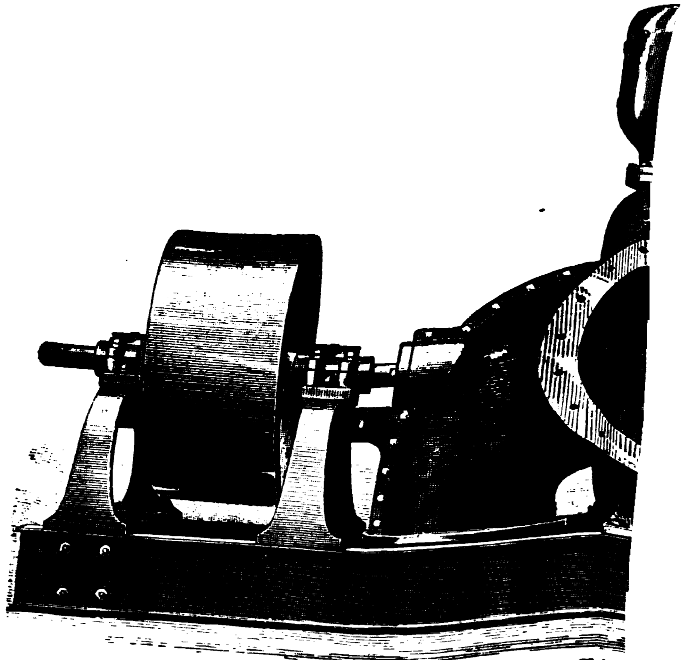


FIG. 12.—Leffel w

downward through a single central draft tube of
design of the standard Leffel wheel which have b
gates and correspondingly wider buckets. This a
capacity for water, and consequently a largely incr
affording a concentration of power in a smaller spac

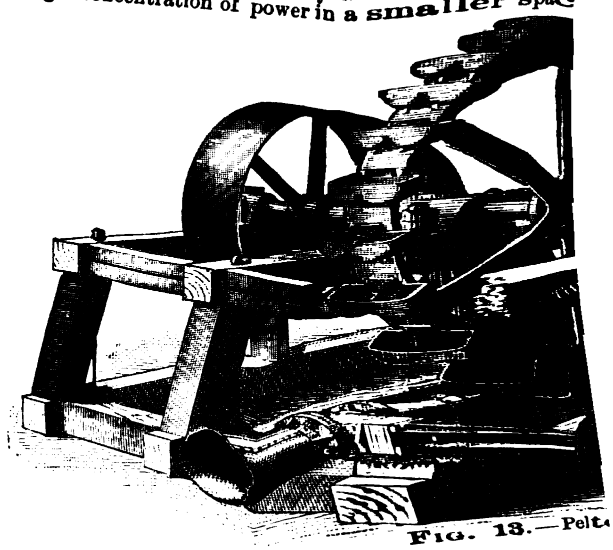


FIG. 13.—Pelt

The Pelton Wheel.—A novel type of wheel of a
been recently introduced on the Pacific Coast. It i
streams of water, and has given very good results.
It might be approximately described as havin

the buckets of a turbine." Its general construction will be readily understood from 13. The important feature is the peculiar construction of the bucket, which is illus-d in section, Fig 14, and in perspective, Fig. 15. The bucket is in form of a paraboloid, has a central wedge which splits the entering jet of water. This jet then passes to the

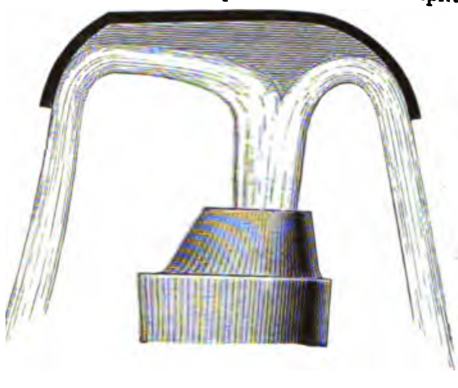


FIG. 14.—The Pelton bucket.

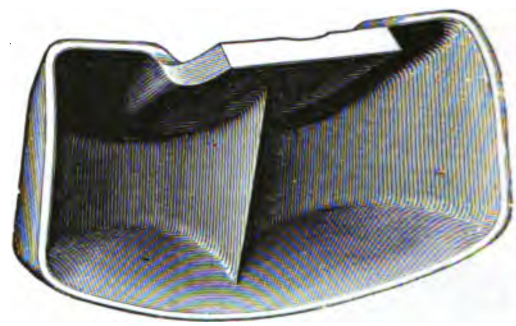


FIG. 15.—The Pelton bucket.

ght and left, following the curve of the bucket, and is discharged at its periphery, having nparted all its energy and motion to the wheel, and falling away as dead water. Mr. Ross . Browne, hydraulic engineer of San Francisco, who has tested this wheel, reports an effi-ency of 82·6 per cent. under 50-ft. head, with a 15-in. wheel, and says that the velocity of he bucket should be one-half that of the jet. Other tests of a 6-ft. wheel, by Messrs. Ed-ard Coleman and George Fletcher, in 1884, showed an efficiency of 87 per cent. In this case he velocity of bucket as compared to the theoretical velocity of jet was about 52 per cent.

The great simplicity and economy of construction of this wheel commends it to atten-ion, and it is especially available for *very high* heads and very small volumes of water. In he last test quoted, the head of water was 380 ft., the diameter of pipe, 22 in., and the liameter of nozzle through which it was delivered was 1·89 in. The power obtained is tated as 107 horse-power, and the revolutions of wheel per minute, 255½. The water used s stated as 2·819 cub. ft. per second, or 169·14 cub. ft. per minute.

Now, the Leffel 6½-in. wheel, one of the smallest turbine wheels in use, would use this amount of water under 100 ft. head, give 27·3 horse-power, and make 2,080 revolutions per minute. This shows the advantage of this wheel in reducing the number of revolutions to a more practical point, by the use of very small buckets on a wheel of large diameter. Were a turbine to be especially constructed for such a head, a 12-in. wheel, having a diam-eter of 8 in. at central point of discharge, would require to make 2,900 revolutions per min-ute to bring its velocity of discharge to that of the "*vena contracta*" under 380 ft., although a turbine of larger diameter, with small apertures, might undoubtedly be designed for the purpose, like Mr. Foumeyron's celebrated turbine of St. Blaise.

The Pelton wheel has proved especially efficient in the electrical transmission of power, and, as is illustrated in Fig. 16, may be placed directly on the dynamo shaft. The full-page illustration represents an electric lighting station in which all the dynamos are driven by these wheels. As examples of the use of the wheel for driving dynamos, the following may be noted: The power station of the American River Syndicate is located at Rock Creek, Eldorado County, Cal. The plant consists of an 8-ft. Pelton wheel, which, running under a head of 110 ft. at 100 revolu-ns with a 5½-in. nozzle, has a maximum capacity of 130 horse-power. To this wheel is nnected a 100 horse-power Brush generator, speeded at 900 revolutions, the current from

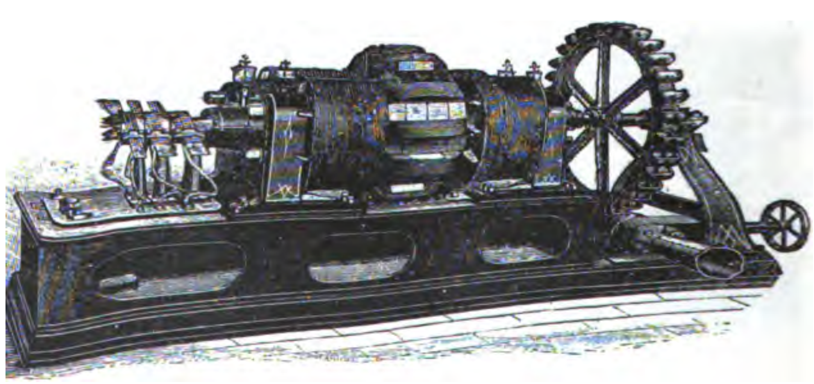


FIG. 16.—Direct driving of dynamo by Pelton wheel.

which is carried to the mill through a single i the return being made by a wire of the same size from the generator is communicated to the cou Brush motor running at 950 revolutions. The ma ugal roller mills, a ten-stamp battery, and a rock conditions shows an efficiency of 86 per cent., wh generated is available for duty at the mill. Suffi to run sixty incandescent lamps for lighting the e

It only remains to be said that the modern tu perfection that, with proper attention to correct v sages, from 80 to 85 per cent. of the gross powe secured by 8 or 10 of the most popular types of wh

Way, Balancing : see Balancing Way.

WELDING, ELECTRIC. One of the oldest portions, when softened or rendered plastic by hea weld together. Owing to this property, the earlie of moderate size from the granules obtained in the operations. These were carried on on too small a portion of carbon conferring fusibility, or cast-iro warm wax, pitch, or heated glass, possess the pr This is probably due to the existence of a compar of materials in a plastic condition, which allow particles or surfaces brought very near together, For such operations of welding, the surfaces mu or dirt, or the conditions must be such that these the operation. With platinum or glass in the hea with great facility, owing to the non-oxidability of such a metal as iron, which forms a scale of bla perature for welding must either be so high that t from the joint or surfaces brought together; or, take place, a flux which dissolves and renders liqu ture is required. In still another way—namely, outwardly from the joining surfaces—the conditio may be secured. The application of the heating mechanical manipulation, marks a recent advanc known ease with which electrical currents may be tributes greatly to the success of the operation.

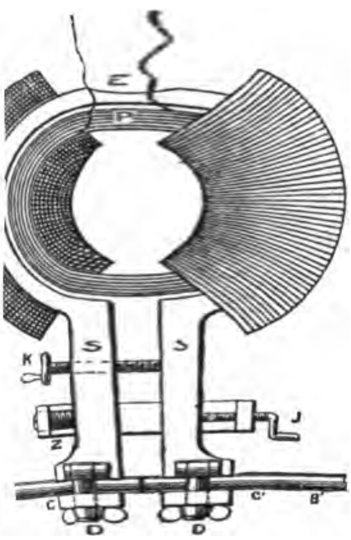
The principles of the Thomson process of el some modifications, applied to the operations o riveting, etc., may be briefly stated as follows: suitable clamps or supports, and provision made tricity at very low pressures or potentials through rent usually enters by the holding-clamps, though are used to pass current into the pieces. Indee merely contact surfaces bearing on the work-pie cations are made in the devices employed so as to result of passing a heavy current through the met ing effect of the currents to the joint itself, or, and at a small distance each side of it. During th together in firm contact, and since there is no a the solid metal, and not by that of any air or ga the heating altogether depend on the fact that such imperfect fit giving increased resistance at would be heated between such clamps, though its of any break or partial fit of surfaces in contact. electric circuit depends upon the resistance which of current passing. It is also in proportion to th

If the resistance be great, a small current will will need to be high enough to force the current t

$$\text{Current} = \frac{\text{E. M. F}}{\text{Re}}$$

But if the resistance in the circuit be low, the cu increased, while the pressure, or electro-motive fo in the case of two bars or pieces of metal held tog rent when passed will only go through the pieces metal each side thereof, a very low resistance wil the pieces. Hence the desired heating for weldin rate of flow of electricity be very high. This cu little more in diameter, or with bars of iron of se weld, may reach thirty or forty thousand amper causing such flow may be no more than two volt the strength of current and pressure depend on rate of heat development, and other factors. I

, currents at the low pressure indicated above, the development of the art has shown
rage cells or accumulators may be used, that dynamo-electric machines may be
cted to furnish the currents, or that currents of comparatively high pressure and
low may be transformed or exchanged by induction apparatus for currents of very
essure and great volume. The latter method is the one adopted in almost all of the
itus constructed for practical use in electric welding. It enables the dynamo, which is
y made to furnish alternating currents of about 300 volts pressure, to be placed
it is convenient to drive it by power, while the working apparatus or welding
'ormer may be elsewhere located, two wires of moderate section being used to convey
irrent from the dynamo to the transformer. The dynamo may be of such size as to be
supply current at the same time to several welding transformers, or welders, as they
lled, and located in different parts of a manufacturing establishment.
e general character of the apparatus may readily be seen by an examination of Fig. 1, which represents the second machine made, and which machine has become historic.



1.—Electric welding machine.

The primary, *P*, Fig. 1, is a large, open ring, and is composed of many turns of insulated copper wire. The secondary, *S S*, is simply a single heavy bar of copper bent to make only one turn outside the primary coil; its ends are turned outward, and provided with powerful screw clamps, *C C'*, for holding the pieces, *B B'*, in place and in abutment. The form of the secondary is somewhat like a Jew's-harp, with the clamps on the ends of the parallel portion. The bar, *S*, is thinned at *E*, and broadened there so as to give a certain flexibility. A powerful screw and spring at *Z J* forces the clamps together when the apparatus is used. Over both primary and secondary a heavy sheathing of iron wire is wound, forming virtually an endless magnetic circuit of iron around them. The iron wire is wound upon a casing which encloses the two coils, *P* and *S*, and prevents the iron wire from interfering with the free movement of the parts of the bar, *S*, and the clamps, *C C'*. The resistance of the secondary bar is about .00003 ohm. Vigorous alternating currents, of comparatively high potential, passing in the primary circuit, *P*, generate in the bar, *S*, when its circuit is closed by pieces, *B B'*, to be welded, a low electro-motive force acting over a circuit of very low resistance, and giving rise therein to currents of enormous volume. To prepare the pieces for the operation of welding by electric means, all that is necessary to be done is to clean those parts of the pieces which enter the clamps by filing or
and to see that the ends or surfaces to be welded are clean enough to effect a contact
pressed together after placing in the clamps. The shape of the abutted ends matters
as a joint will be formed even when the ends are irregular, but it is better to have the
es either flat or with the edge chamfered a little, or with one or both surfaces made
hat convex, in order that the joint may begin in the middle of the abutted section.
eces are placed in the clamps, with the ends to be joined projecting therefrom a small
t, and a moderate pressure tending to hold them in abutment, is applied. Sometimes
stage a flux, as borax, is added, after which the current is put on. Heating of the
d ends at once begins and proceeds with a rapidity depending on the current flow, and
e and nature of the pieces treated, reaching the welding heat or temperature of union
metal, or even reaching the point of actual fusion. With great energy of current,
on iron bars of over ½ in. diameter have been made in less than three seconds after
ig the current, and with small wires the action is almost instantaneous. The scale on
the apparatus is constructed depends, of course, on the character and dimensions of the
to be treated or worked. Wires of $\frac{1}{16}$ of an inch in diameter up to bars of several
in diameter may be welded by suitable sizes of welders. The current strength required
case depends on the nature of the metal or alloy as regards fusibility, specific heat,
nce, etc. Easily fused metals, like tin or lead, require less current, because the tem-
re of welding is just short of their fusing points, which are, of course, comparatively
hile their higher specific resistance to the flow of current, as compared with iron or
, still further lessens the current required to produce the heat in any given section.
metals silver and copper, which, in their pure state, are the most perfect electrical
tors known, and which at the same time possess a very high heat-conducting power,
for electric welding currents of relatively much greater amount than do iron,
m, gold, etc. The conductivity for heat tends to cause a rapid transfer of heat from
it to the clamps during the operation, which loss of power is largely kept down by
the weld in as short a time as possible. The conducted heat, as well as the heat
ed by the current in passing from the clamps or current-applying contacts to the
iece to be welded, tends to raise the temperature of the clamps or contacts, and so in
ure lessen their efficiency for conveying current, and also to injure them by oxidation.
parts of the apparatus being usually of copper, or alloys rich in copper, are, however,

:onvex, and the heating and welding therefore begins in the center, or near the axis of bar. As the metal heats, softens, and yields, the weld continues to spread laterally until ncludes the whole of the section. It has been proved possible to weld bars without lucing any expansion or burr at the joint by first preparing the ends suitably—*i.e.*, by first removing from the ends of the pieces just that portion of metal which during the welding would have gone to form the expansion. However, this operation requires skill and judgment, and is not generally practised. The degree of heat to which a bar may be brought in the electric welder is only limited by the fusing point of the metal, unless the losses by conduction and radiation from pieces too large for the machine, limit it. The fact that most metals when heated possess less conductivity for current is important, for it lessens the volume or flow of current required to be passed. Otherwise the current would need to be increased as the section welded was increased during the operation. This, however, is not requisite, for in the case of iron, as an example, the specific resistance of the metal at the welding heat may be ten to twelve times what it is at ordinary temperatures. This fact has also another important bearing on the operation of electric welding, for it leads to a uniform distribution of the heating effect in the different parts of the weld, assuming that no disturbing ct which otherwise prevents such uniformity exists. The action is briefly that if in a d one portion of the meeting surfaces is comparatively cooler than another, its resistance l be less, more current will therefore be diverted to such cooler portions, and a consent increased heat production will ensue thereat which rapidly brings the metal to a perature nearly uniform with the rest.

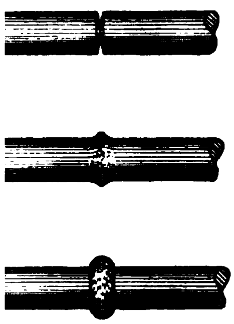


Fig. 2.—Butt welding.

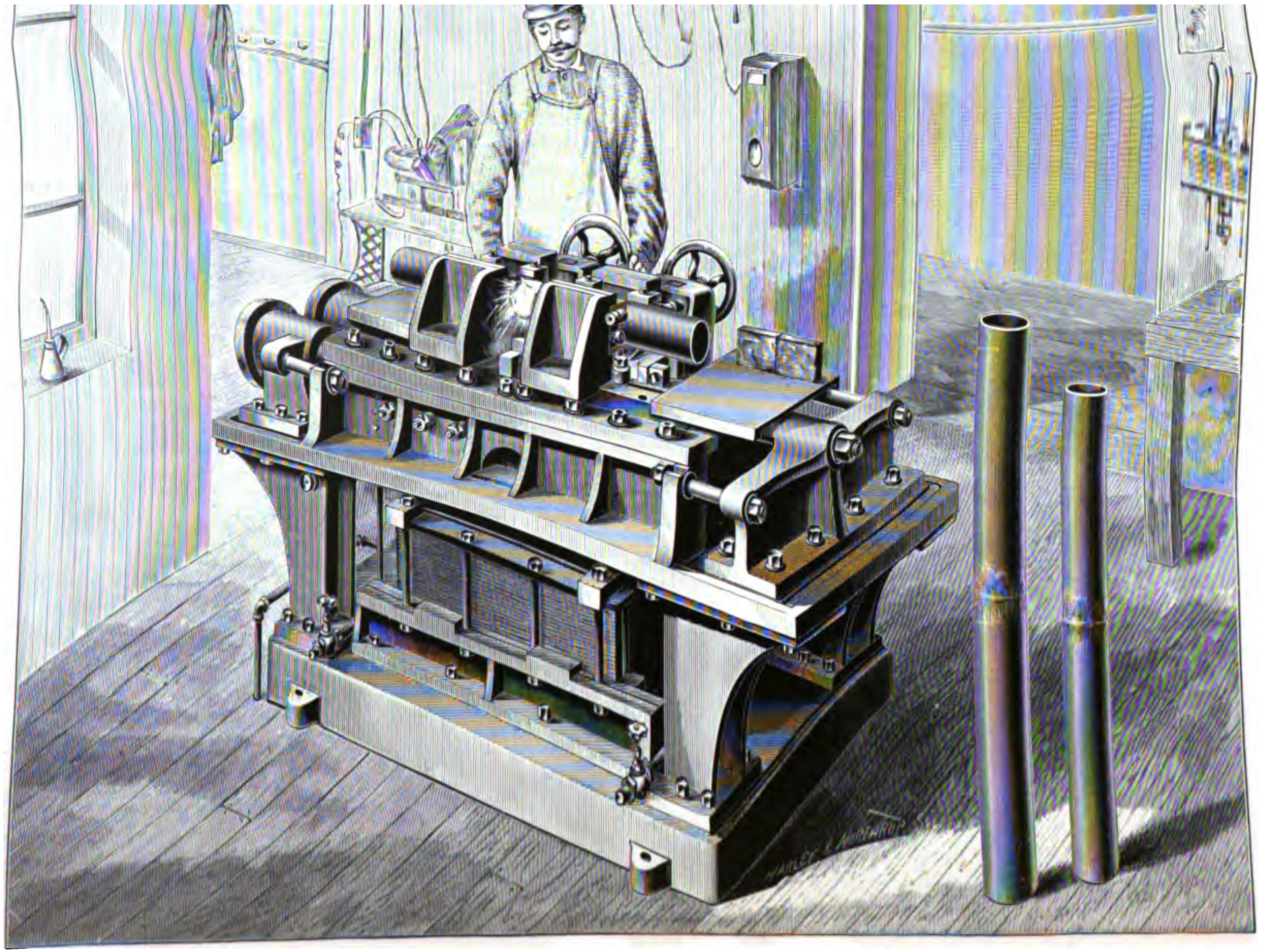
The development of the Thomson electric-welding process has shown that instead of a only of the metals and alloys being the weldable ones, there are few if any exceptions ong the metals so far as their weldability by electricity is concerned. It has appeared also t in many cases metals are united with great ease which before were regarded as nondable. Doubtless the reason for this is that the perfect control of temperature and prese obtained enables the operator to work within so much narrower limits of fusibility and sticity as would be impossible with the ordinary methods. The metals which have been nd to weld with facility include wrought-iron, cast-iron, steels of various grades, steel tings, Bessemer metal, copper, lead, tin, zinc, nickel, cobalt, silver, gold, platinum, antiny, bismuth, magnesium, aluminum, manganese, cadmium, and such alloys as cast and ed brass, bronze, gun metal, aluminum brass, aluminum bronze, phosphor bronze, silicon nze, coin silver, gold of varying fineness, type metal, pot metal, pewter, solder, German er, fuse alloy, aluminum iron, etc. The process permits the combination of different tals and alloys to be effected without solder, such as copper to brass, copper to soft iron, per to German silver, copper to gold, copper to silver, brass to soft iron, brass to cast-iron, to zinc, tin to brass, brass to German silver, brass to tin, brass to mild steel, wrought to t-iron, wrought-iron to cast-steel and to mild steel, gold to German silver, gold to silver, d to platinum, silver to platinum, soft iron to cast brass, iron to German silver, iron to kel, tin to lead, etc.

The joining is frequently effected without the use of a flux, though in some cases a flux, h as glass of borax, is found to assist the operation. The energy required to effect a weld f course different with the different metals, according to conductivity for heat and eleclity, fusibility, section, shape of pieces, and other factors.

The following table shows some of the results obtained in welding iron, etc., and with time occupied in the work.

Energy absorbed in Electric Welding. Professor Thomson's process.

Iron and Steel.					Brass.					Copper.				
Area in sq. in.	Watts in primary of welders.	Time in seconds.	Horse-power applied to dynamos.	Foot lbs., unit 1,000.	Area in sq. in.	Watts in primary of welders.	Time in seconds.	Horse-power applied to dynamos.	Foot lbs., unit 1,000.	Area in sq. in.	Watts in primary of welders.	Time in seconds.	Horse-power applied to dynamos.	Foot lbs., unit 1,000.
·5	8,550	33	14·4	260	·25	7,500	17	12·6	117	·125	6,000	8	10·	44
·	16,700	45	28·0	692	·5	13,500	22	22·6	281	·25	14,000	11	23·4	142
·5	23,500	55	39·4	1,191	·75	19,000	29	31·8	508	·375	19,000	13	31·8	227
·	29,000	65	48·6	1,738	1·	25,000	33	42·0	760	·5	25,000	16	42·	369
·5	34,000	70	57·0	2,194	1·25	31,000	38	52·0	1,087	·625	31,000	18	51·9	513
·	39,000	78	65·4	2,804	1·5	36,000	42	60·3	1,390	·75	36,500	21	61·2	706
·5	44,000	85	73·7	3,447	1·75	40,000	45	67·0	1,659	·875	43,000	22	72·2	872
·	50,000	90	83·8	4,148	2·	44,000	48	73·7	1,947	1·	49,000	23	82·1	1,039



THE THOMSON PROCESS OF ELECTRIC WELDING.

It will be seen that the foot pounds of ener
as much again as with the same section of iro
not very different. The high heat conductivit
the length of bar is heated, or more heat condu
for the difference noted. It may also be rem
rapidly than the section, and in a certain propo
the larger pieces, though less subject to radiat
pieces, there is required a longer time for t
conduction of heat from the joint results.
for varying sections, it would appear that the
tion to the section. The end pressure in for
work, be carefully kept, as, if a proper amount
on the metal pieces arriving at a certain deg
the heating simply governing the time whic
ticity. The pressure to be applied in effecting
and section of the pieces at the weld. It is
wrought-iron, about 1,200 lbs.; and for copper,

In the industrial application of the proce
special dynamo, constructed to deliver alternating currents at about 300 volts, and of a periodicity of about 50, or 100 alternations per second. Where but a single welder has been employed it has been customary to regulate the welding currents by varying the field-exciting current by a resistance or other device. Fig. 3 shows a plan of the connections used in such a case. Fig. 4 also shows the arrangement of a composite-field self-exciting dynamo, which is controlled
by a variable reactive coil alongside the wel
ture branch or circuit, which in turn causes a

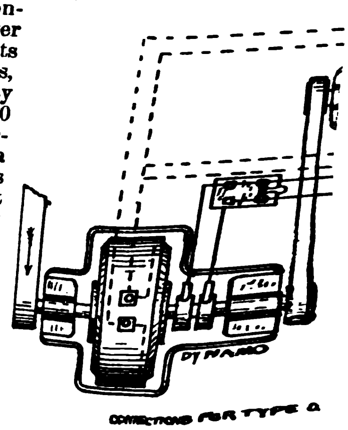


FIG.

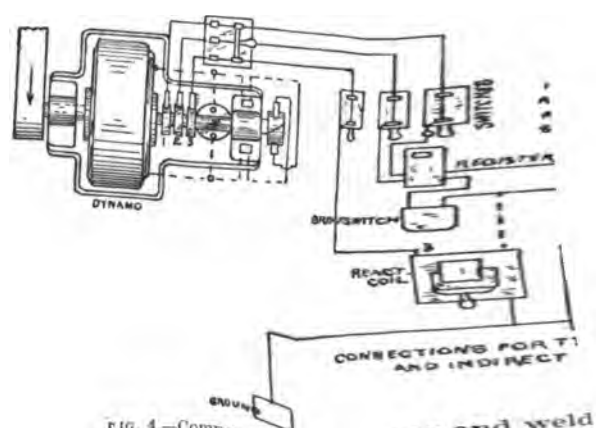


FIG. 4.—Composite field dynamo and weld

The actual construction used in the we
according to the size and character of the work
and nature of movement to be given to the clan
the construction of the welder itself to a la
may be regarded as a special induction coil

y are the l relation placed in the special welder, where they are united very accurately in their but little finishing being required to complete the work. The application of the electric welding process to wire jointing being one of the earliest and simplest cases, has become very extended, and millions of joints are annually made in wires of various size and of different metals. The joints are usually as strong as the annealed metal, or nearly so. When the wires to be united possessed a structure due to working, such as drawing through the draw plate, it is, of course, not to be expected that such structure will be retained at or quite near the joint welded electrically, as the heating anneals the wire and takes away the grain or toughness conferred by the mechanical kneading of drawing, rolling, or hammering. In such cases it is customary, where it is practicable, to hammer the joint after welding, special devices, delivering numerous quick blows of small hammers, being made for the purpose. Drawing subsequent to welding restores the structure, and the hammering is then not usually required. The application of the process to the production of chain effects a saving in weight, inasmuch as mild steel may replace wrought-iron, and, therefore, yield a chain of equal strength of less weight and cost. The uncertainty of steel welding by the ordinary process has been a bar to the use of ordinary forge welding, and electric welding, on the other hand, enables the milder steel to be employed with almost the same facility as wrought-iron. The electric process also enables bars or pieces of such shape of section as could not be worked by the ordinary welding methods, to be dealt with easily, and hence finds a wide field of application special to itself, in addition to its use for the ordinary work of bar welding, as in tires, axles, etc., pipe welding, etc. Machinery of the same general character as electric welding machines is applicable to use in electric soldering and brazing. In such cases the current is passed through one or both pieces, so as to bring them up to the temperature at which the solder melts. In the presence of a suitable flux, the operation can generally be performed with great facility and rapidity. A number of such machines have been put in operation. They possess the advantage of localizing the heat almost solely in the portions of metal at the joint, as in electric welding. In consequence, the extensive scaling of partly finished surfaces on each side of a brazed joint (such as occurs with the fire or blow-pipe often employed) is prevented, and the heating action is under the most perfect control. The clamps for holding the work may, of course, remain stationary in the case of electric soldering or brazing, though they are often made movable and adjustable for the placing of the pieces in proper relative positions prior to the heating.

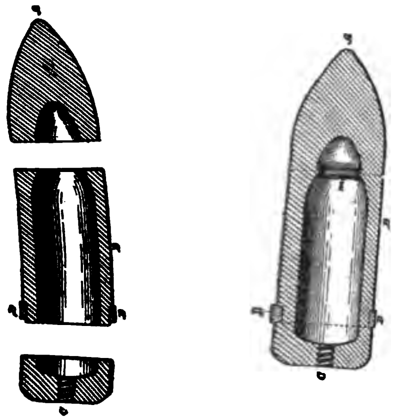


FIG. 10.—Welded projectiles.

The welding machinery is also applied with but slight modifications (generally of a purely mechanical nature) to such operations as electric forging and shaping, including upsetting and riveting. The portions of metal to be heated for such operations are included between the terminals of the heavy secondary, and are quickly brought to the proper working heat by the passage of the heavy current. After this, either by a movement imparted to the pieces clamped and heated, or by separate dies or formers, the desired shape is given to the plastic metal, and the pieces may be heated and pressed a number of times in succession, in case the nature of the work is such as to require it.

The operation of electric riveting is a form of upsetting, and is accomplished by making the rivet blank the path for the heavy secondary current. For this purpose, it is only necessary to include the blank, with or without head, between the heading tools of heavy bronze or copper, kept cool by water circulation through them, and when the blank has reached a plastic state by the current heating it, to force the tools one toward the other until the heads are sufficiently formed (Fig. 11). With sufficient energy of current the rivet body actually welds into the plates, and the plates themselves may, in part, be welded together. The heating of pieces for hot spinning or rolling may be accomplished, and the rotation of the pieces even during the passage of current, presents no considerable difficulty. The apparatus in this case resembles a lathe, the heads of which are insulated, and then connected to the terminals of a secondary circuit of a transformer of the same construction as for welding. The tool post, or the part corresponding thereto, carries rolls or formers for manipulating the revolving hot metal, through which the current is passed for heating, and the working may proceed while the heating is in progress. The heat may also be maintained at the proper degree for giving the requisite plasticity or continuous annealing. In this way iron tubing rotated may be reduced or expanded, its ends closed, beads rolled in its sides, etc.

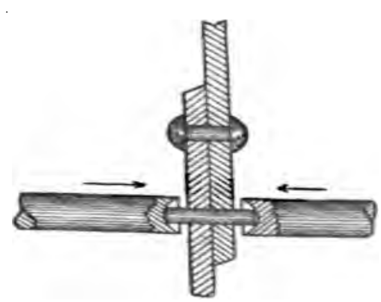


FIG. 11.—Electric riveting.

Adapting the strength of the current, or rather the heating effect of the current, to the size of the pieces in electric welding, brazing, forging, shaping, etc., is a matter easily provided for by suitable regulators. Where the pieces included in the circuit are of different sections or resistances, they will not heat

equally, unless special precautions are taken, such as proportion each piece, or arranging the conduction, or cooling of the pieces o in greater degree the piece of higher resistance, which would, s In welding, this is frequently done by giving but a relatively clamps to the piece of smaller section or higher resistance.

In some instances in practical work it has been found that electrical welding can be obtained by heating the pieces to a red the clamps of the welding machine, which then raises the tempe and only at the joint. This, for special kinds of work, may be required for the incipient heating during welding. Frequently, are wastes of other parts of the manufacture can be employed to welding. and, of course, where water-power is abundant the ene turned into heat for the same uses.

Welding Tubes : *see Pipe and Tube-making Machines.*

WHEEL-MAKING MACHINES. The manufacture of whe impulse in America by reason of the superiority of our native demands made upon wheeled vehicles by our poor roads; and in our machine designers and builders have nobly met the call ma scarcely any part of a wheel which is not now made by machinery among the ingenious and productive machines for making and ass reckoned the felly and rim sawing, rounding, planing, mortising, spoke lathes, tenoners, and throaters; hub turning, boring, finishin special machines for inserting and driving the spokes, trimming driving screws into the felly, and cutting off their ends; wheel pres

In one of the cutting-off, boring, and doweling machines made dant Co., the spoke tenon-boring device has a hollow mandrel, wh reciprocating motion, and a sliding mandrel inside this, which has so that it may be brought forward to the work without in any w truth of the journal and bearings of the outer rotating mandrel brought up to the boring bed, such a precaution is not necessary.

In the Egan double spoke-throating machine, the upright colun slides, and a mandrel fitted to each slide and carrying a cutter hea exact shape to hollow out the part of the stock which is to come a cutter heads are placed at a certain distance apart. The spoke is pla which has pins against which the spoke rests, and which carry the st heads. On the outer end of the rotating table there are two cams, end of the spoke to work up and down, giving the desired shape to t

In some machines to accomplish this purpose, the cutter heads an center; but on this one the stock is made to adjust up and down, stationary.

In the manufacture of fellies there is usually employed a machine dished saws on the same mandrel, at a distance apart governed by th the felly; and the material, is clamped on a sector, the radius of whi and the centre so placed, that when the stock is swung around to the a there will be cut a rim having concentric inner and outer edges employed for fellies of different radii. It should be mentioned in thi plane in which the sector bearing the stock has its vibration is not pa which the saw arbor lies; thus, if the saw arbor is horizontal, the secto horizontal to a degree corresponding to the distance above the saw cen is presented.

Rim Planer.—A machine for planing wheel rims or fellies on operation, either straight or bevelled, is brought out by the Bentel calls for a very different construction from that required in ordinary ments are that it shall plane all the four sides of a felly or of th diameter and thickness, with continuous feed and without splintering of the fellies or rims. It consists of a horizontal table, with a geared adjustment that the center line of the feed roll points to the center of felly, no matter for what diameter of wheel, gripping the felly in the circle, and feeding it in that line—thus, of course, lessening the fricti giving greater immunity from stoppage. There are two horizontal on which work the two sides of the felly or rim. Their housi bed plate, on which they can be set to any required angle or b accordance with a scale placed in the bed plate. The bed plate a vertical line by a crank and screw. The housings thus arra resetting for bevel or angle, but retain the given angle for wide or a change in the bevel is desired. The table back of the lower cutt lower bracket, and can be raised and lowered to suit the desired or vertical cutter housings are so arranged that the outside cutter de inner side of the felly, remains fixed, while the inside one, which h adjusted for thickness. pl

A Felly-rounding Machine made by the Bentel & Margedant Co heavy column, cast with the journals all in one piece, with a wide b parted so as to give one bearing on the front and the other on the ba

›oming in the space between, and the mandrel pulley between the two journal boxes. tight and loose pulleys are outside of the frame, so that the belt connection may be e from either above or below. There are two horizontal turned bars, one each side of the frame top, forming a support for a half-circle side guide, which may be adjusted thereon for wide or narrow fellies. The circular side guides may be adjusted for greater or less distance apart while the machine is in motion. The one on the back is wider than the front one, but both fit close to the circle of the cutter heads. The center guide or rest between the two cutter heads, on which the felly rests, can be raised or lowered at will during the operation of rounding. The cutter-heads are of the Denison pattern, and the head in which they are held is shown in Fig. 1.

Fig. 1.—Felly-rounding machine.

The Bentel & Margedant Felly-boring Machines have an arrangement for the accurate and positive clamping of the felly, doing away with trouble on account of the irregularity of the spoke holes. The felly rests on two steel straight-edges, which afford it only two resting places, establishing the height of each hole uniformly from the face of the straight-edges, regardless of any twist or bend in the sides of the felly. A double clamp, operated by a treadle, presses the felly uniformly against the stop bars at two points on the inside of the felly, establishing thereby an accurate and uniform angle for each hole. On the left side of the treadle there is an adjusting spacer, for spacing the holes accurately after the first one is bored; and this is set to point toward the center of the felly arc, so that the holes will be laid off accurately.

A felly-boring and screwing machine made by the same company consists in the main of vertical column bearing a cross arm, at the short end of which there is a vertical boring mandrel having vertical feed by a balanced lever. The same cross arm bears a spindle, having a detachable screw-driver, encased by a countersunk cup for leading the screw head to the screw driver, or a milled grip cup, which takes hold of the rim of the screw at several points and drives the screw into place; this latter method of taking hold of the screw being preferred, as it is quick in action and does away with the danger of splitting the head. Both the boring and the screwing mandrel are worked by the same lever. By raising it, the boring spindle, which runs twice as fast as the screw-driver spindle, descends and bores the hole; then pushing the lever down, the boring spindle is raised and the screw-driver spindle lowered, driving the screw into the felly. The spindles are connected by a chain, which may be unhooked if desired. The rim of the wheel rests, during the operation, upon a small adjustable table; the hub being held by a chuck with jaws, operated by a screw. Adjustment for wheels of different diameters and thicknesses is effected by a rod passing through the column connecting with the wheel holder, being movable in and out by a hand lever. By running wood screws into the felly where the tenon of the spoke enters, the splitting of the former is prevented.

The enormous development of special machinery may be pointed out by one, for instance, which is intended to supersede the heretofore annoying operation of cutting off that part of the screw head which remains projecting on the face of a wheel after the felly or rim screw, used by many manufacturers to bind and strengthen the rims or fellies of wheels, is driven home. In one of these machines, made by the Bentel & Margedant Co., the wheel is placed on a short upright mandrel, which is adjustable horizontally to suit different wheel diameters; and the internal surface of the felly is presented to the action of two heavy shears, having tool-steel dies, one of which is stationary as to movement, but adjustable for taking up wear. The other shear is in exact line with an opposite or stationary shear, and has a reciprocating movement to and from it. By this action the projecting part of the screw will be cut off close to the face of the rim, when the wheel is properly set and the screw head brought between the jaws of the shears. The wheel itself rests upon an adjustable pivot, upon which it can be moved up and down, back and forward, and set at an angle, thus permitting changes for various sizes and kinds of wheel. The machine is driven by a pulley on a horizontal shaft, which by beveled wheels drives the cutting mechanism through a short vertical shaft.

The Bentel & Margedant Wheel-polishing Machine is used for producing a finish on the treads of large wagon wheels; it sands, sizes, and polishes both sides of the wheel at one operation. The wheel holder consists of a planed base sliding on flat surfaces to and from the sanding disks, to accommodate large and small wheels; and to this base there are pivoted upright rigid double-ribbed supports for the wheel chuck; these supports being swung to and from the sanding disks by a treadle, for entering and withdrawing the wheel. On one side there is a centering chuck with adjusting jaws and scroll gearing. On the opposite side is a large scroll chuck, which centers from the hub, and holds and rotates the wheel while it is being sanded. Each sanding disk has its own mandrel and housing, and the latter can be set for any bevel of rim, an index scale showing the amount of bevel per foot. The disks adjust to and from each other for different rim thicknesses, and after being

set can be thrown together or drawn apart by a hand lever ... being withdrawn and another one placed in the machine. ... number of pieces cut to size are put on each disk in layers, one o... screw ring, without glue; and when one layer is worn out this ... top layer of sandpaper picked off with a pointed instrument, and ...

The Automatic Hub-turning Machine shown in Fig. 2 is sp... to ... carriage and wagon hubs up to 20 in. diameter, and 18 in. ... cuts in the rough state, roughs, turns, cups, finishes the ends, ope... for the bands, and makes the hubs of any shape or size, at one ... The fram... in two parts. The lower half is gibbed and fitted to the whee... adjustment horizontally in line with the mandrel, by hand and ... knives with the hub block. The upper table, with roughing slides f... end, is mounted upon and gibbed to the lower table, and ... angles with the mandrel by turning the large hand wheel, to bri...

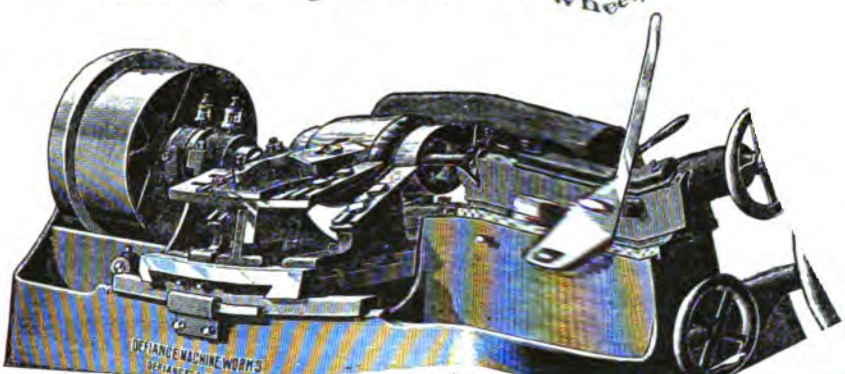


Fig. 2.—Automatic hub-turning machine.

the finishing knives to the hub block. The roughing knife, with a ... long, is held in a stand at the back of the sliding carriage, with its cutt... downward, and when working takes off surplus material from the hub b... a ribbon ⅛ in. thick, the full length of the hub; the gauge governing t... feed. The finishing knives are at the opposite end of the carriage fron... their cutting edges extending upward, consisting of the body knife wi... shaped to correspond with the style of hub to be turned; and a flat k... upon the same stand, for cutting the front and back bands, with adjus... bands of different widths and diameters. The cutting-off knives, for fini... the hub, are on separate stands, below and in advance of the body and b... cupping attachment is gibbed to the tail stake and provided with a gaug... depth of the cut. The shape of the knife governs the style of cup. A fric... the hub, the frictions being disengaged by a treadle.

The Automatic Hub-turning and Finishing Machine shown in Fig. 3 is f... turning plain, beaded, banded, Sarven, and Warren hubs complete, with ... The rough hub block is placed in the machine, which first roughs it down to the proper size by a roughing knife having a straight face 12 in. long, and which is fastened to a stand at the back end of the sliding carriage, with its cutting edge extending downward, taking off a ribbon about ⅛ in. thick of the full length of the hub at one cut, a gauge limiting the depth of cut. By a reverse movement of the hand wheel, the roughing portions retreat and the finishing knives come into play, the diameter to which they turn being regulated by screws attached to the carriage, so that, once adjusted, the machine turns out hubs of only one finished diameter. The finishing knives are at the opposite side of the carriage f... and their cutting edges extend upward. At each end, upon the same sta... knives, are the knives for cutting band seats; on separate stands, the knive...

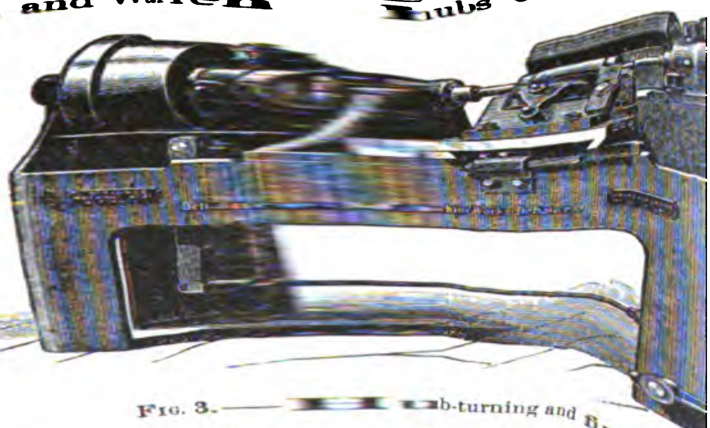


Fig. 3.—Hub-turning and finishing ...

these last being in advance of the body and band knives. A single set of knives will nd finish hubs of the same shape to any diameter within the machine's capacity. The s by friction.

ne hub-boring machine shown in Fig. 4, and made by the Defiance Machine Works, is boring hub blocks up to 12 in. diameter and 15 in long. The block may be ted with the hard or soft part central with the boring bit, regardless of its external shape. The removal of this soft part keeps the block from checking when seasoning, and adds to the value of the product. The carriage is gibbed to the frame, and slides to and from the boring bit by turning the hand wheel 30°. The jaws which receive the hub are mounted upon the sliding carriage, the boring tool traveling through the jaws. The jaw at the back part of the machine can be adjusted to receive hubs of various lengths, and is connected with the hinge joint. The upper end is fitted ith a weighted eccentric lever to open and close the jaws. In operation, the end of the oring tool should extend slightly through the hole in the first jaw, the operator centering ne end of the block by the boring tool, the other end being set by the hole in the jaw at the ack part of the machine; then the weight of the lever will hold the block while being bored. he capacity is 200 blocks per hour.

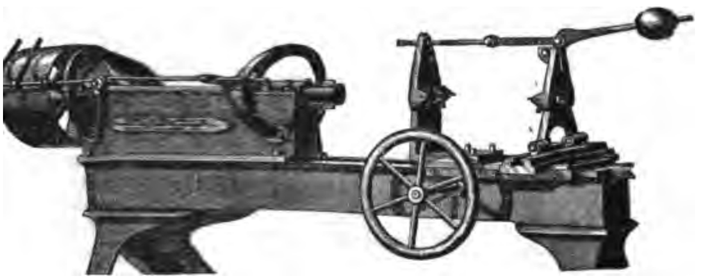


FIG. 4.—Hub-boring machine.

The Heavy Hub-boring Machine shown in Fig. 5 receives the hub block between powerful niversal jaws, which hold it central with the boring tool. In boring, the soft central part the block is removed. By the use of solid steel reamers, the hole is bored in the block omplete at one operation to the proper size, and tapered to fit the hub lathe mandrel upon hich the block is to be turned and finished. The hub block is placed in and removed from

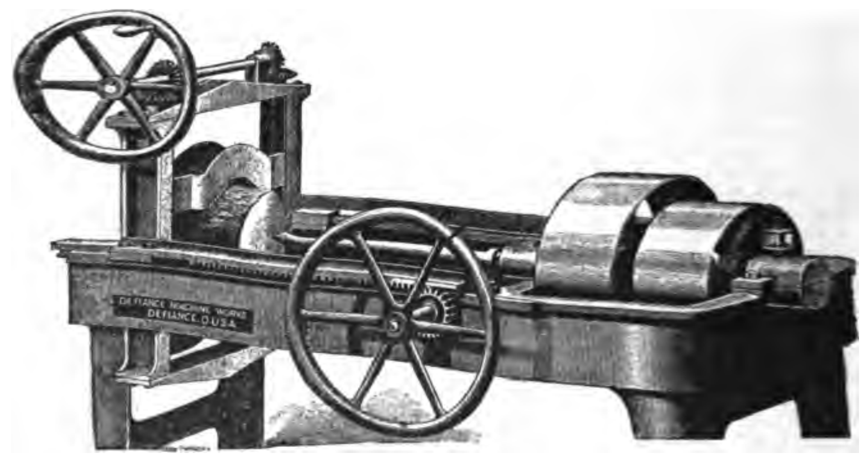


FIG. 5.—The heavy hub-boring machine.

he jaws when the carriage is moved to the back end of the machine, which is open, so that he material may be handled without lifting it over the frame. In operation the hub is lamped between the jaws, which are self-centering, and is presented to the action of the eamer by turning the large hand wheel shown.

Wheel-box Making.—In cutting the seat for the box in a wheel hub there are two rincipal methods—in one of which the cutter remains at rest, the wheel turning at slow peed around the advancing but not rotating cutter-head; in the other both the wheel and he cutter-bar turn. To turn a wagon or buggy wheel at high enough speed to do free utting is impracticable by reason of the wheel not being in accurate balance for high speed, o that it would either fly apart or fly from the wheel chuck. The method of slow turning of the wheel about a non-rotating cutter is claimed by many to tear and splinter the ood, and so disturb the fiber as to shorten the life of the hub, as the spokes and box an not be given firm support in the disarranged fiber.

The Bentel & Margedant Wheel-boxing Machine.—In this machine, Fig. 6, the wheel is rned slowly to secure perfectly true center cutting, but the cutter is also rotated at high

speed. There is a solid cast column, having a double slic
center line of the whole machine. The bed plate resting o
and forth across the machine by a large hand wheel in fro
of the cutter-bar in exact line with the center line of the wh
of either side of this center line. The advantage ari
the carriage into or across the center line of the wheel chuck
cutters or reamers of the exact diameter of the hole desired,
diameter than the cutter by moving it out of center. I
recessing the hole between the hub ends, cutting away the
that they will not rest on the box, and producing offsets or
shape of the box. For angular or tapering shapes of wh
provided, independent of this, but which can be operate
consists in arranging the lower adjustable sliding bed plat
circular turning slide, to which the long cutter-bar carria
rotating slides, permitting the carriage to be swiveled. By t
bar slide on which the cutter-bar housings travel can be thi
cutting the sides of the box angular or beveled, to conform t
In connection with the movement of the bed plate across

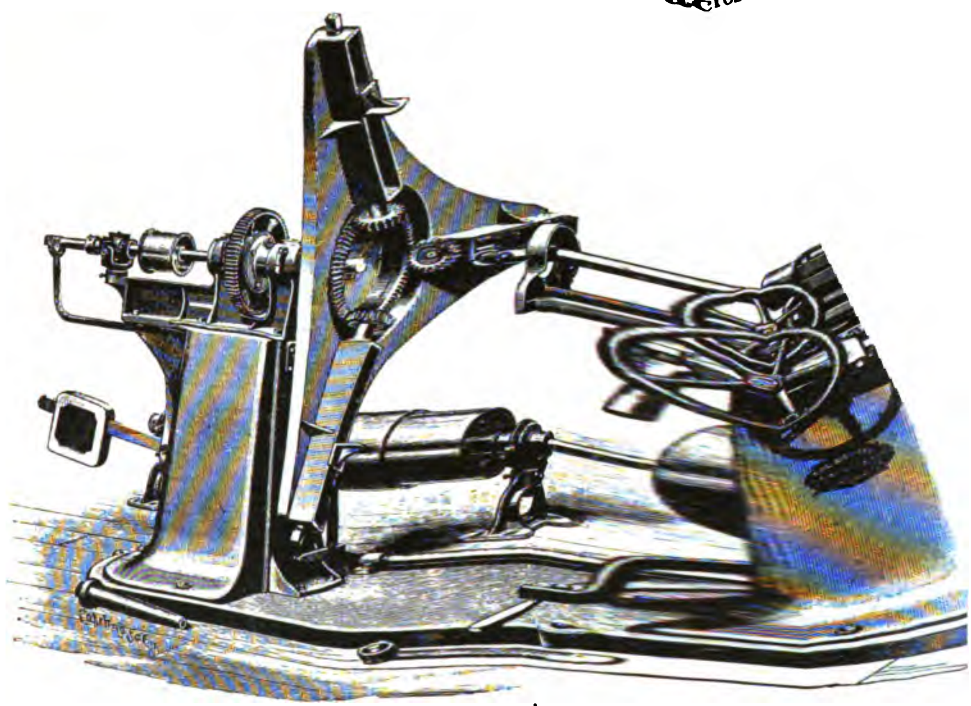


Fig. 6.--Wheel-boxing machine.

admits cutting wide, narrow, or angular sides or offsets in
tric clamp operated by a lever on the inside of the machin
plate, changes from straight to taper boring. The cutter-b
the long carriage slide by dovetailed slides, giving a moveme
for the cutter-bar and its housing. This movement is under
may be made fast or slow by hand or by power, at will. The fe
whole length of the carriage, and is constantly turned by a la
carriage. There is in line with the carriage, a small hand wl
wheel fitting closely into the threads of the feed screw, and by t
cutter may be moved to and from the hub at the speed given by t
wheel, so that the cutter may enter and return from the hub a
By grasping and holding the hand wheel at rest, not turning it
feed is brought into action, and the cutter-bar started forward at a
large feed pulley. The framing of the machine consists of two
The column bearing the chuck for the wheel is at the back or
hand or front one carrying the boring tool. The wheel chuck c
nected heavy arms, each having the movable clamp block operated by
the common central circular rack. By applying a socket wrench
one of the three clamp screws, the three clamp blocks may be move

and at the same time. The wheel is clamped at the rim while resting on planed plates, thus securing a true position, being guided by three points of the rim. The wheel chuck has a hollow mandrel resting in two bearings, an adjustable rotating bearing being provided in its rear, taking the weight of the chuck from its bearings. The cutter-bar for finishing the front or end of the hub passes through the hollow chuck mandrel, and has its own bearings and pulley, and movement back and forth for cutting the "crozing" of the hub. It is operated

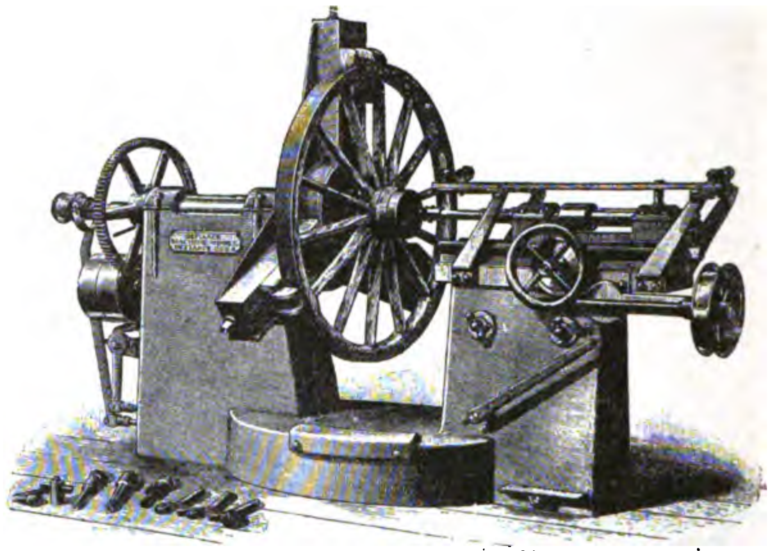


FIG. 7.– Automatic wheel-boxing machine.

by a treadle placed near the operator's stand at the front of the machine by the shifter bar controlling the chuck belt.

The Automatic Wheel-boxing Machine shown in Fig. 7 is for boring and finishing the hole in a wagon hub for receiving the boxes, doing this at one cut to any regular or irregular shape, relieving the center of the hub around the spokes, and cupping both ends of the hub to any desired shape. All these operations are done at one starting and stopping. There is a universal chuck fastened to a 6-in. spindle, all three of the dogs of which are actuated at once by turning with a wrench any one of the three screw threads, the range being for wheels from 20 to 60 in. diameter. There is a boring bar, having lengthwise and crosswise adjustment, for boring holes of any taper, size, or contour desired; and it has auxiliary cutter-heads to "depth" the backs of the hubs to accommodate the axle shoulder. After completing the cut the feed is disengaged automatically. The boring cutter consists of three independent cutters of square tool steel.

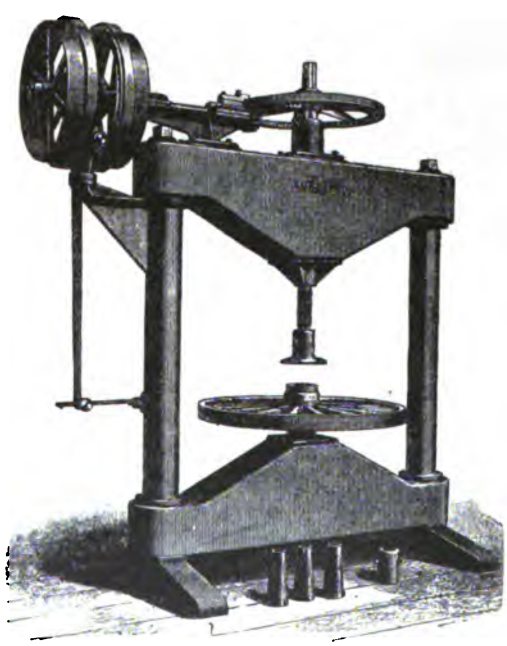


FIG. 8.—Power wheel press.

A Power Wheel Press is shown in Fig. 8, for pressing axle boxes into wheel hubs and pressing bands and flanges thereon; taking the place of the hydraulic presses often used for the same purpose. The screw has an up-and-down movement of 24 in., and the machine will take in a 60-in. wheel, upon which it will exert a pressure of 60,000 lbs. The direction of motion of the screw is regulated by the position of the hand lever which operates the friction clutch.

A hydrostatic power wheel press made by the Be umn, containing the cylinder, and supplied with cruc vertical pumps, operated by eccentrics upon a shaft front of the machine permits the oil to flow from a and the same lever releases the pressure and permits of the pumps. A pop valve permits escape of the reaches 80 tons. The ram rises ⅛ in. for every rotati

WINDLASS, STEAM CAPSTAN. Fig. 1 represe lass, manufactured by the American Ship Windlass become almost exclusively adopted on American vess following: The valves of the engines are driven b

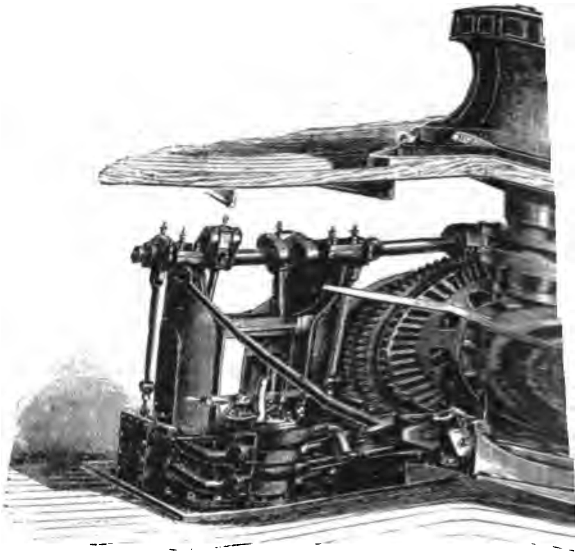


FIG. 1.--Steam capstan

shafts. There is a steam reverse valve for reversing ropes. The solid center bearing of the main shaft is prevent any springing of the shaft under sudden st power is transmitted directly from engine to windlass and windlass are connected to one plate, by which t can not get out of line. If the deck above twis away, the windlass can still be efficiently operated by which constantly applies oil to the teeth of the worm gear, and a crank-shaft counterbalance, which balances the weight of the cranks, pistons, and rods, and prevents jerking motion, are added. The general construction is simple, strong, and effective. A detailed account of the mechanism will be found in the United States patents for the device, granted July 31, 1888, and March 14 and July 2, 1889.

The Ravelli Windlass, Fig. 2, consists simply of a strong iron frame, of a bevel gearing, whose pinion is keyed to the winch shaft, and of a pair of helicoidal gearings. Upon the shaft that connects the two bevel wheels is keyed a drum, provided with dep which the load to be lifted is attached. The endles do not, as usual, run around the entire circumfere them covers but a quarter, and if there are six,

whole. this endless screw constitutes a sort of a disk, upon the circumference of which ged a variable number of pins that are slightly inclined with respect to the bases of At every fraction of a revolution corresponding to the number of the pins, one of ndom as the tooth of the gearing while the following pin and tooth engage. In order nish passive resistances, the teeth do not rub against the inclined planes formed by s, but roll over them. To this effect, they consist of truncated cone spindles loose ournals set firmly into the felly of the gearing. The wear of these spindles is slow, e they are numerous and engage at relatively wide intervals of time. The power of achine is very great, although no recourse is had to a differential mechanism nor to . Stoppage is secured under full load, either in the raising or lowering of weights, out the intervention of any stop-work or brake. No flying back of the winch is to be d, and this gives every security to the workman.

Wire Belting: see Belts.

Wire-cord Quarrying: see Quarrying Machines.

Wire Rope: see Rope-making Machines.

WIRE STRAIGHTENING. The ordinary method of straightening wire is by means olls, between which the wire is drawn, and which are adjusted by means of thumb-ws to bear heavily upon the bends. Another device is known as a rotary straightener, which there are three pairs of dies, the middle pair being set out of line with the end rs. The wire is carried through the dies, and the dies themselves are rotated, producing rking motion, the effect of which is to straighten out kinks, etc. A variety of auto-tic machines for wire straightening is described in a previous volume of this work, and se have not undergone any very material changes of late years.

An entirely new method of wire straightening, however, has been invented by Mr. n Wool Griswold, of Troy, N. Y., in which the use of machinery is entirely dispensed h. The wire, as it comes from the draw bench, is placed upon any suitable rotary support. then led through an annealing furnace of any suitable construction. Here it is ex-ed to the air, for a considerable interval of space, until it finally reaches a pair of mov-rolls, through which it passes. The rolls draw the wire from the reel and through the nace, delivering it upon a table, where it is cut into lengths by a descending knife. Dur-the passage of the wire through the furnace, and also through the air space, it is kept ler tension by the action of the roll; and in this way it is made straight. As the wire is lly cut into lengths, no coiling is necessary. This process has been found exceedingly ective, especially in the manufacture of wire into bale bands at the factory of Messrs. iswold Bros., in Troy, N. Y.

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THE END.